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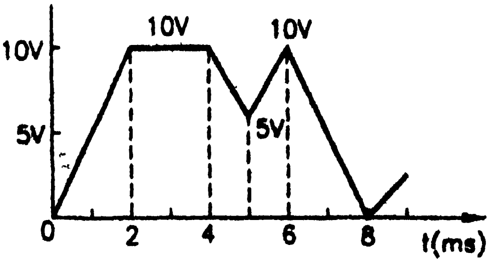
ENGINEERING SERVICES EXAMINATION 1996 (E & T)

PAPER I (Conventional)

Time Allowed : Three Hours **Maximum. Marks : 200**

1. (a) A voltage source with waveform as shown in Fig. 1(a) is connected across a 30 mF capacitor at time $t = 0$. Find the values of the current in the capacitor at $t = 0.5$ ms and $t = 2.5$ ms. Also calculate the total energy delivered by the source till $t = 7.0$ ms. The capacitor has no charge prior to $t = 0$. (8)



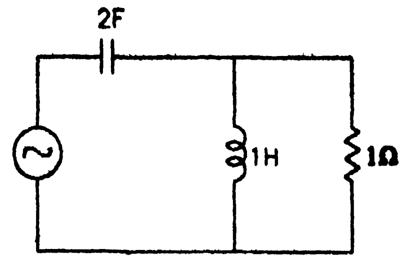
(b) Find the electric field vector E for an isotropic dielectric material when the displacement vector

$D = D_x i_x + D_y i_y + D_z i_z = 5.0\,(i_x + i_y - 2i_z)$ pC/m^2 and E is related to D as

$$\begin{bmatrix} D_x \\ D_y \\ D_z \end{bmatrix} = \varepsilon_0 \begin{bmatrix} 4 & 2 & 2 \\ 2 & 4 & 3 \\ 2 & 2 & 4 \end{bmatrix} \begin{bmatrix} E_x \\ E_y \\ E_z \end{bmatrix}$$

following usual notations. (8)

(c) Calculate the frequency at which the circuit of Fig. 1(c) will be in resonance. Will this frequency change if the positions of the inductor and capacitor are interchanged ? (8)



(d) Find the current i in the circuit of Fig. 1(d) using superposition theorem.

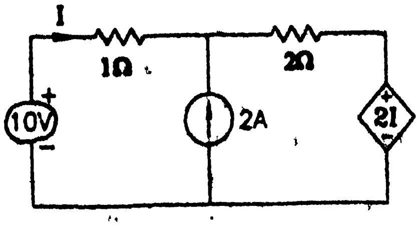


Fig. 1(d)

(e) Given an electric field 30 sin($10^{10}t$ + 15°) v/m, find the conduction and displacement current densities in a material with $\sigma = 4.0$ S/m, $\varepsilon = \varepsilon_0$ and $\mu = \mu_0$. Also determine the frequency (in Hz) at which the two densities will become equal in magnitude. (8)

(f) Determine the group velocity of a 12 GHz signal propagating in the TM_{11} mode in a rectangular waveguide of 4.0 cm × 2.0 cm cross section. (8)

(g) A galvanometer recorder with a 100 Ω coil resistance is connected to a transducer. The transducer acts as a voltage source in series with a 250 Ω resistance. The recorder response to a step input to the transducer is that of a second order system with a damping factor of 0.3. Find the resistance that should be put in parallel with the transducer so that the damping factor increases to 0.7. (8)

(h) The excitation to a two-terminal network is $4 + 5 \sin \omega t + 3 \cos 2\omega t$ volt, while the response current equals $0.3 \cos 2\omega t + 0.1 \cos (2\omega t - 45^\circ)$ A. Find the average power supplied by the excitation source. (8)

HANDBOOK
OF
TEXTILE TESTING

Part 2 Testing of Yarns and Fabrics (Excluding Colourfastness)

(*First Revision*)

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110 002

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FOREWORD

This part of the Handbook consists of five sections dealing with sampling and preparation of test samples/specimens for testing various physical, physico-chemical, chemical and biochemical tests for yarns and fabrics. The brief details of the methods/procedures covered in these sections are given below:

SECTION A

Contains the procedures for sampling and preparation of test samples/specimens for determination of physical and chemical characteristics of various textiles yarns and fabrics.

SECTION B

Contains conditioning of textiles; physical tests for yarns for various characteristics such as linear density, twist, strength parameters, commercial mass, unevenness, etc; and physical tests for fabric characteristics such as length and width, threads per unit length, weight per square meter and weight per linear meter, thickness, strength parameters, crease recovery angle, pilling resistance, air permeability, stiffness, thermal resistance, drape and abrasion resistance etc. These methods of test are essential for controlling the quality, durability and end use suitability of various yarns and fabrics.

SECTION C

Contains physico-chemical tests for yarns and fabrics for characteristics such as residual shrinkage, dimensional changes, wettability, absorbency, water repellency, water resistance, etc, which are useful in determining end use suitability of the yarn or fabric.

SECTION D

Contains chemical tests for determining various chemical characteristics such as chemical content in textile materials, scouring loss, residual starch, properties of aqueous and organic extracts of textile materials, preservatives on textiles, soil resistance flammability and flame resistance, *p*H value, viscosity (or fluidity), copper number, etc. It also includes tests for coated fabrics for characteristics such as mass of coating material, uniformity of coating, total solid content of coating materials, flexibility and effect of ageing.

SECTION E

Contains biochemical tests for detection and estimation of damage in textile yarns and fabrics due to micro-organisms and for determination of resistance of yarns and fabrics to attack by micro-organisms.

The various methods of test included in this part of the Handbook are based on current national and international standards.

The Indian Standards partaining to various test methods included in this part of the Handbook have been brought out by the following Sectional Committees :

TX 01 : Physical Methods of Test
TX 02 : Cotton and Cotton Products
TX 03 : Jute and Jute Products
TX 04 : Wool and Wool Products
TX 05 : Chemical Methods of Test
TX 06 : Man-Made Fibre and Products

A number of test methods on coated and treated fabrics formulated by the Coated and Treated Fabrics Sectional Committee of the Petro-Chemical Department of BIS have also been added. It would be pertinent to mention here that test methods for evaluation of physical characteristics for silk yarn and fabrics have not been included. These are under revision and it is intended to issue a separate compilation for the same at a later date.

INTRODUCTION

BIS Handbook of Textile Testing (SP 15:1981) was first published in 1982 and has been taken up for revision to incorporate additional methods based on the standards which have come out after its publication. Opportunity has also been taken to incorporate latest version of the standards which have since been revised. The Handbook is now being brought out in four parts wherein standards have been grouped on the basis of application and use:

Part 1 Testing and Grading of Textile Fibres
Part 2 Testing of Yarns and Fabrics (Excluding Colour Fastness).
Part 3 Testing of Textile Products Other Than Yarns and Fabrics.
Part 4 Identification and Testing of Dyestuffs and Their Colour Fastness on Textile Materials

The Handbook is basically a compilation of various Indian Standards on methods of test published by various Sectional Committee under Textile Division Council. There are more than 300 standards covering a wide range of physical and chemical characteristics of textiles covered in the Handbook. Besides some methods of test and which are included in the product specifications and no separate standards have not been published are also included in the present version of the Handbook wherever appropriate. As such the methods of test included in the Handbook would satisfy the requirement of various sectors of textile industry like testing laboratories, research institutions, educational institutions in as far as the testing of the products like handloom and *khadi*, powerloom, hosiery, carpets, readymade garments, dyestuffs, textile auxiliaries, ropes and cordage, industrial textiles, aerospace textiles, etc, is concerned.

The objects of the Handbook are to :

- give the user details on all published national standards on methods of test for textiles;
- help the various users to establish a suitable quality assurance system in the organization;
- serve as a guide for the ordinary consumer to know the characteristics of textiles which are important with reference to its end use; and
- assist the textile technology/chemistry students, educational and research institutions in the selection of the appropriate methods of test for various in depth studies/research.

Every effort has been made to make the various parts and sections self-contained but in certain cases relevant provisions have been extracted and reproduced. In all such cases, for detailed guidance, reference should be made to individual standards and in case of any contradiction observed between the Indian Standards and those reproduced herein; the provisions of the former should be considered accurate. On one hand, the Handbook is expected to be a self-contained reference document where as on the other, it is desirable to keep it less voluminous. The present version of the Handbook is the judicious choice with respect to the two aspects referred above.

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SECTION A

SAMPLING AND PREPARATION OF TEST SAMPLES/SPECIMENS

SAMPLING OF COTTON YARN FOR DETERMINATION OF PHYSICAL CHARACTERISTICS

(*Source* : **IS 3920 : 1985**)

1 SCOPE

It prescribes the procedure for sampling of cotton yarn for determination of physical characteristics, namely, count, lea breaking load, twist, evenness percentage and appearance grade. It specifies the number of tests that should be made for each characteristic. It also lays down the criteria for ascertaining the conformity of the yarn to the specified requirements of the characteristics.

2 NUMBER OF TESTS

2.1 The minimum number of tests to be made for determination of average values of various characteristics of yarn in a lot shall depend upon the accuracy with which the averages are to be determined. Table 1 gives the number of tests necessary for determination of average values of count, lea breaking load, evenness and twist for varying limits of error.

NOTE — Limit of error of mean is the maximum difference between the sample mean and its true value (that would be obtained if all the units in the lot were tested) at a given probability level.

2.1.1 Unless otherwise agreed to between the buyer and the seller, 25 tests for count, and lea breaking load and 10 tests for evenness and twist shall be made for evaluation of average values.

2.1.2 For inspection for appearance grade five packages shall be selected at random from a lot and one test specimen shall be prepared from each package. As far as possible equal number of packages shall be selected from each bale/case. When the number of bales/cases is 8 or 13 five bales/cases shall be selected at random and from each bale/case one package shall be selected.

2.2 The minimum number of tests to be made for determination of coefficient of variation of various characteristics of yarn in the lot shall depend upon the accuracy with which the coefficient of variation (CV) is to be determined. Table 2 gives the number of tests necessary for determination of coefficient of variation of count and lea breaking load for varying limits of error.

NOTE — Coefficient of variation (CV) is the ratio of the standard deviation to the absolute value of the mean expressed as percentage. Limit of error of CV is the maximum difference between the CV of the sample and true value of CV (that would be obtained if all the units in the lot were tested) at a given probability level.

Table 1 Number of Tests
(*Clauses* 2.1 *and* 3.3.1)

Characteristic	Limit of Error of Mean (Percent)						
	2	3	4	5	6	8	10
Count	25	15	10	5	–	–	–
Lea breaking load	100	45	25	20	15	10	5
Evenness percentage	80	35	20	15	10	5	–
Twist	65	30	28	10	7	5	–

NOTE — Wherever the number of tests have become too small they have not been specified.

Table 2 Number of Tests for Determination of CV
(*Clauses* 2.2 *and* 2.2.1)

Limit of Error of CV (Percent)	Number of Tests
(1)	(2)
4	1 200
5	800
8	300
10	200
15	90
20	50
30	25

2.2.1 It can be seen from Table 2 that 200 tests are required for determination of coefficient of variation with an accuracy of 10 percent. However, for a manufacturing concern, the coefficient of variation can be determined from routine tests conducted over a period of time to any degree of accuracy required.

3 SAMPLING

3.1 Test specimens shall be sampled from each lot for determination of physical characteristics of yarn. In order that the test specimens selected be representative of the lot, they shall be distributed over the bales or cases in the lot, packages in a bale or case and skeins of yarn within packages. Unless otherwise agreed to between the buyer and the seller, the number of bales or cases to be taken from a lot for the purpose shall depend upon the size of the lot and be in accordance with Table 3.

Table 3 Number of Bales or Cases to be Chosen from a Lot

(*Clauses* 3.1, 3.3.1 *and* 5.1)

Lot Size (Bales or Cases)	No. of Bales or Cases to be Chosen
(1)	(2)
2 to 8	2
9 to 15	3
16 to 25	5
26 to 50	8
51 and above	13

3.2 The bales or cases shall be selected at random from the lot, and in order to ensure the randomness of selection of the bales or cases, the procedure given in IS 4905: 1968 'Methods for random sampling' shall be followed.

3.3 From each selected bale or case approximately equal number of packages shall be chosen at random for drawing specimens for test.

3.3.1 The minimum number of packages to be selected from any bale or case shall be determined by dividing the number of tests to be conducted (*see* Table 1) by the number of bales or cases selected (*see* Table 3). If it comes out to be a fractional number, its integral part (say, r) shall be taken and r or ($r+1$) packages shall be chosen from each selected bale or case so as to get the requisite number of packages for tests. In case the minimum number of tests happens to be less than the number of bales or cases selected, one or more packages shall be taken from each bale or case so as to get the number of packages selected to be an integral multiple of 5 just greater than the number of bales or cases chosen.

3.4 From each of the packages selected, one test specimen shall be taken for determining the various characteristics. While drawing the test specimens care shall be taken to exclude at least 20 m of yarn from the ends. The test specimens thus collected from different packages shall constitute the test sample.

3.5 The specimens thus selected shall be subjected to relevant tests for determining the different characteristics.

4 CRITERIA FOR CONFORMITY

4.1 The lot shall be declared conforming to the requirements regarding average values for various characteristics, if the calculated average value meets the relevant requirement of the standard.

4.2 The lots shall be declared conforming to the requirements of coefficient of variation if the calculated value of CV is less than the maximum limit specified.

5 ILLUSTRATIVE EXAMPLE

5.1 A consignment of 30 cases of cotton yarn of 40s count according to IS 171:1993 'Ring spun grey cotton yarn for weaving' was delivered to a buyer who desires to ascertain the conformity of the lot to the requirement of count. IS171:1993 specifies that the tolerance of ± 3 percent on average count and the maximum CV (percent) of 5.

According to Table 3, the number of cases to be selected for drawing packages are 8 and the number of tests to be carried out are 25 according to **2.1.1**. Thus, three packages each of yarn are drawn, from seven of the cases selected and four packages from the eight case. One test specimen is prepared from each package thus selected.

The test results obtained on the test specimen thus selected are given below:

39.8	38.8	39.2	39.2	39.8
41.2	39.5	38.2	38.5	41.2
40.5	40.0	40.5	40.5	39.5
39.5	39.5	39.5	38.5	40.0
42.2	40.2	40.8	39.5	38.5

The mean, the standard deviation and the coefficient of variation are calculated as given below:

$$\text{Mean } (\bar{x}) = \frac{39.8 + 41.2 + \ldots + 40.0 + 38.5}{25} = \frac{994.6}{25} = 39.78$$

$$\text{Sample standard deviation } (s) = \sqrt{\frac{\Sigma x_i^2 - \frac{(\Sigma x_i)^2}{n}}{n-1}} = \sqrt{\frac{39591.44 - \frac{(994.6)^2}{25}}{24}} = \sqrt{0.9281} = 0.96$$

$$\text{CV (Percent)} = \frac{0.96}{39.78} \times 100 = 2.4$$

It can be seen that the requirement of IS 171:1993 are met by the lot.

METHODS FOR SAMPLING OF COTTON FABRICS FOR DETERMINATION OF PHYSICAL CHARACTERISTICS

(*Source* : IS 3919 : 1966)

The increase in indigenous production and export of cotton fabrics has made it imperative to evolve sound sampling procedures for objective and economic evaluation of physical characteristics of cotton fabrics. For this purpose, extensive amount of information had been collected from the different textile mills and research organizations in the country and the inherent variability of various characteristics ascertained. This method recommends the number of tests as obtained on the basis of the resulting data for determining various characteristics with a specified degree of accuracy.

1 SCOPE

It prescribes the procedure for sampling of cotton fabrics for determination of physical characteristics, namely, ends, picks, width, length, thickness, weight, breaking load and bursting strength. It specifies the number of tests that should be made for each characteristic. It also lays down the criteria for ascertaining the conformity of the fabrics to the specified requirements for the characteristics.

2 NUMBER OF TESTS

2.1 The minimum number of tests to be made for determination of various characteristics of fabrics in a lot shall depend upon the accuracy with which the characteristics are to be determined. Table 1 gives the number of tests for determination of ends, picks, width, length, thickness, weight, breaking load and bursting strength for varying limits of error.

NOTE — Limit of error of mean is the maximum difference between the sample mean and its true value (that would be obtained if all the units in the lot were tested) at a given probability level

Table 1 Number of Tests

(*Clauses* 2.1 *and* 3.3.1)

Characteristic	Limits of Error of Mean (Percent)				
	3	4	5	6	8
Ends Picks Width Length	10	5	–	–	
Weight Thickness	15	10	5	–	–
Breaking load Bursting strength	30	20	15	10	5

NOTE — Where the number of tests have become too small, they have not been specified.

2.2 Unless otherwise agreed to between the buyer and the seller, the number of tests corresponding to 3 percent error for ends, picks, width and length; 4 percent for weight, 6 percent for thickness and 8 percent for breaking load and bursting strength shall be taken for all routine testing.

3 SAMPLING

3.1 The pieces shall be sampled from each lot for determination of physical characteristics. In order that the pieces selected are representative of the lot, they shall be distributed over the bales in the lot. Unless otherwise agreed to between the buyer and the seller, the number of bales to be taken from a lot for the purpose shall depend upon the size of the lot and be in accordance with Table 2

Table 2 Number of Bales to be Chosen from a Lot

(*Clauses* 3.1, 3.3.1 *and* 5.1)

Lot Size	No. of Bales to be Selected
(1)	(2)
2 to 8	2
9 to 15	3
16 to 25	5
26 and above	8

3.2 The bales shall be selected at random from the lot and in order to ensure the randomness of the selection of the bales the following procedure shall be adopted.

3.2.1 A set of random numbers from 1 to 100 is given in Table 3. Any one numeral shall be selected at random from the table. Starting from the selected numeral and continuing on with the numerals in any direction, right or left, up or down, the succeeding numerals shall be copied out one by one till the number of numerals is equal to the number of bales to be chosen. The numerals which are greater than the size of the lot or which have already occurred shall be omitted. The numerals noted down in this manner shall be arranged in the ascending order of magnitude.

Table 3 Random Number Table

(*Clauses* 3.2.1 *and* 5.1)

81	74	67	95	70	56	51	54	50	53
61	37	42	62	93	96	34	18	22	88
52	07	16	29	39	04	71	14	76	78
43	08	77	25	72	49	86	03	83	45
65	32	27	40	63	57	97	84	82	87
21	58	11	23	80	10	30	01	100	44
31	90	55	88	13	36	24	91	19	64
73	98	20	05	68	46	69	85	94	59
33	15	35	26	79	92	38	12	41	17
75	66	99	09	06	47	48	60	28	02

3.2.2 Starting from any bale in the lot and counting them in one order, the bales corresponding to numerals already noted down shall be selected from the lot for drawing samples.

3.3 From each selected bale approximately equal number of pieces shall be chosen at random

3.3.1 The minimum number of pieces to be selected from any bale shall be determined by dividing the number of tests to be conducted (*see* Table 1) by the number of bales selected (*see* Table 2). If it comes out to be a fractional number, its maximum integral part (say *l*) shall be taken and *l* or (*l*+1) pieces shall be chosen from each selected bale so as to get the requisite number of pieces for tests. In case the minimum number of tests happens to be five and the number of bales selected to be eight, one or more pieces shall be taken from each bales so as to get ten pieces for test purposes.

3.4 In case the lot is not in the form of bales or cases but offered as pieces as such, the number of pieces to be selected at random from a lot for testing for a particular characteristic shall be equal to the number of tests required to be carried out according to **2**.

3.4.1 To ensure the randomness of selection of pieces the procedure given in **3.1** or **3.3** of IS 4905 : 1968 'Methods for random sampling', shall be followed.

3.5 From each of the pieces selected, one test specimen shall be taken for determining the various characteristics. While drawing the test specimens care shall be taken to exclude a suitable length from both ends of the piece.

3.6 The test specimens thus selected shall be subjected to relevant tests for determining the different characteristics.

4 CRITERIA FOR CONFORMITY

4.1 For ascertaining the conformity of the lot to the specification requirements, the following procedure shall be adopted.

4.1.1 *For One-sided Specification Limit*

The lot shall be declared as conforming to the specification if:

a) the value of the expression $(\bar{x}+kR)$ or $(\bar{x}+k\bar{R})$ is less than or equal to U, when the upper specification limit U is given; or

b) the value of the expression $(\bar{x}-kR)$ or $(\bar{x}-k\bar{R})$ is greater than or equal to L, when the lower specification limit L is given;

where the values of the factor k are given in Table 4 for different sample sizes, and U and L refer to the specification limits for individual test result.

4.1.2 *For Two-sided Specification Limit*

The lot shall be declared as conforming to the specification if:

a) the value of the expression $R/(U-L)$ or $\bar{R}/(U-L) \leq B$;

b) the value of the expression $(\bar{x}+kR)$ or $(\bar{x}+k\bar{R}) \leq U$; and

c) the value of the expression $(\bar{x}-kR)$ or $(\bar{x}-k\bar{R}) \geq L$;

where the value of factors B and k are given in Table 4 for different sample sizes, and U and L refer to the specification limits for individual test results.

NOTE — The explanation of various symbols is given in Annex A.

Table 4 Values of the Factors

Sample Size (*n*)	*k*	*B*
(1)	(2)	(3)
5	0.3	1.0
10	0.4	0.9
15 and above	0.5	0.8

5 ILLUSTRATIVE EXAMPLE

5.1 A seller delivers to a buyer a consignment consisting of 50 bales, of which 20 bales consist of cotton umbrella cloth (waterproof) and the remaining 30 bales consist of cotton brill (non-waterproof) for umbrella. The buyer desires to ascertain the conformity of the fabrics supplied to the specification requirements of $130^{+6.5}_{-3.2}$ g/m² and $150^{+6.5}_{-3.2}$ g/m² respectively with regard to weight per square metre.

For the purpose of sampling and testing, the consignment shall be divided into two lots one consisting of 20 bales of waterproof umbrella cloth and other of 30 bales of non-waterproof drill. The weight per square metre of the fabric shall be determined for each lot separately. The procedure for selecting the sample and determining the conformity is explained below with reference to the first lot only, a similar procedure to be followed in case of the second lot also.

The number of bales to be chosen from the lot containing 20 bales for drawing the specimens for test shall be 5 according to Table 2. In order to select the 5 bales at random from 20 bales in the lot, random numbers as given in Table 3 shall be used. Suppose the numeral 03 occurring in the fourth row and eighth column is chosen at random. Proceeding further in any direction, say right, and enumerating the numerals which are not greater than 20, the numerals encountered are 03, 11, 10, 01, 13. Arranging them in ascending order, the sequence 1, 3, 10, 11, 13 is obtained. Then, starting from any bale, the bales in the lot shall be counted in one order and the bales corresponding to these numbers shall be withdrawn from the lot for selecting the pieces from them.

According to **2.2** and Table 1, ten tests corresponding to four percent error shall be required for determination of the weight per square metre of the fabric in the lot. Since the number of bales selected is 5, two pieces shall be chosen from each bale for carrying out the tests.

Let the test results (in g/m²) be as follows:

132, 134, 131, 129, 133, 135, 132, 128, 130, 134.

The mean ($\bar{x}$) of the test results is then obtained as:

$$(\bar{x}) = \frac{132 + 134 + \ldots\ldots + 134}{10}$$

$$1\,318/10 = 131.8 \text{ g/m}^2.$$

The mean range ($\bar{R}$) of the test results shall be calculated by taking the ranges of the first five and the last five test results. Thus,

$$\bar{R} = \frac{5 + 7}{2} = 6 \text{ g/m}^2$$

Now the weight per square metre has been specified to be $130^{+6.5}_{-3.2}$ g/m² thereby leading to the lower (L) and upper (U) specification limits of 126.8 and 136.5 g/m² respectively. According to **4.1.2**, it is then found that:

a) the values of the expression $\frac{\bar{R}}{U - L}$ comes out to be $\frac{6}{9.7} = 0.62$ which is less than 0.9 the value of B given in Table 4 for sample size 10,

b) the value of the expression ($\bar{x} + k\bar{R}$) comes out to be ($131.8 + 0.4 \times 6$) = 134.2 g/m² which is less than the upper specification limit of 136.5 g/m², and

c) the value of the expression ($\bar{x} - k\bar{R}$) comes out to be ($131.8 - 0.4 \times 6$) = 129.4 g/m² which is greater than the lower specification limit of 126.8 g/m².

Hence the lot consisting of cotton umbrella cloth (waterproof) shall be declared as conforming to the specification requirements in respect of weight per square meter.

ANNEX A

(*Note under* 4.1.2)

GLOSSARY OF SYMBOLS

$\bar{x}$ Mean; if $x_1, x_2, \ldots\ldots x_n$ are the n measurements of the items in a sample then

$$\bar{x} = \frac{x_1 + x_2 + \ldots\ldots + x_n}{n}$$

R Range; if $x_1, x_2, \ldots\ldots x_n$ are the n measurements of items in a sample, arranged in the ascending order of magnitude, then $R = x_n - x_1$

$\bar{R}$ Mean range; if $R_1, R_2, \ldots\ldots R_m$ are the ranges of m subgroups of five observations each (so that sample size $n = 5m$) then,

$$\bar{R} = \frac{R_1 + R_2 \ldots\ldots\ldots + R_m}{m}$$

k Coefficient of R or $\bar{R}$ for the criteria for conformity.

B Maximum value for the expression $\frac{R}{U - L}$ of $\frac{\bar{R}}{U - L}$ in criteria for conformity for two-sided specification limits.

U Upper specification limit.

L Lower specification limit.

≤ Less than or equal to.

≥ Greater than or equal to.

SAMPLING OF COTTON FABRICS FOR CHEMICAL TESTS

(*Source* : **IS 5463:1969**)

The increase in the indigenous production and export of cotton fabrics has made it imperative to evolve sound sampling procedures for objective and economic evaluation of various characteristics of cotton fabrics. This method recommends the number of tests for determination of various chemical characteristics with specified degree of accuracy, as obtained on the basis of data collected from different textile mills and research organizations throughout the country.

1 SCOPE

It specifies the methods for sampling of cotton fabrics from bales or cases for chemical tests.

2 NUMBER OF TESTS

2.1 The minimum number of tests to be made for determination of various characteristics of fabrics in a lot shall depend upon the accuracy with which the characteristics are to be determined. Table 1 gives the number of tests for the fabrics manufactured in the country for determination of ash content, copper content, chromium content, proofing content, scouring loss, shrinkage, water soluble matter, water absorption (for water-resistant fabric), wettability and viscosity for varying limits of error. The probability level for the number of tests given in Table 1 varies between 94 and 99 percent.

NOTE — The limit of error of mean is the maximum difference between the sample mean and its true value (that would be obtained if all the units in the lot were tested) at a given probability level.

Table 1 Number of Tests

(*Clauses* 2.1, 3.3.1 *and* 5.1)

Characteristic	**Limit of Error of Mean, Percent**				
	5	6	8	10	15
Ash content	—	30	20	15	5
Copper content	25	20	10	7	5
Chromium content	25	15	10	7	5
Proofing content	25	20	10	7	5
Scouring loss	—	30	20	15	7
Shrinkage	—	25	15	10	5
Water soluble matter content	30	20	15	10	5
Water absorption (for water-resistant fabrics)	20	15	10	5	—
Wettability	—	—	25	15	7
Viscosity	—	30	15	10	5

NOTE — Where the number of tests have become too large or too small they have not been specified.

2.1.1 The number of test for the characteristics, namely, acidity, alkalinity, barium activity number, colour fastness to various agencies, *p*H value of aqueous extract and presence of starch shall be three if the lot consists of 15 or less bales and five otherwise.

2.2 Unless otherwise agreed to between the buyer and the seller, the number of tests corresponding to 15 percent limit of error of mean for ash content, copper content, chromium content, proofing content, scouring loss, water soluble matter content and viscosity; and 10 percent for shrinkage, water absorption (for water-resistant fabrics) and wettability shall be taken for all routine testing.

3 SAMPLING

3.1 The pieces shall be sampled from each lot for determination of chemical characteristics. In order that the pieces selected are representative of the lot, they shall be distributed over the bales in the lot. Unless otherwise agreed to between the buyer and the seller, the number of bales to be taken from a lot for this purpose shall depend on the size of the lot and be in accordance with Table 2.

Table 2 Number of Bales to be Chosen from a Lot

(*Clauses* 3.1, 3.3.1 *and* 5.1)

Lot Size (Bales or Cases)	**No. of Bales or Cases to be Selected**
(1)	(2)
2 to 8	2
9 " 15	3
16 " 25	5
26 and above	8

3.2 The bales shall be selected at random from a lot and in order to ensure randomness of selection of the bales IS 4905:1968 'Methods for random sampling' shall be used.

3.3 From each selected bale approximately equal number of pieces shall be chosen at random.

3.3.1 The minimum number of pieces to be selected from any bale shall be determined by dividing the number of tests to be conducted (*see* Table 1) by the number of bales selected (*see* Table 2). If it comes out to be a fraction, its maximum integral part (say, 1) shall be taken and l or $(l+1)$ pieces shall be chosen from each selected bales so as to get the requisite number of pieces for test. In case the minimum number of tests happens to be less than the number of bales selected, one or more pieces shall be taken from each bale so as to get the number of pieces in multiple of five for test purposes.

3.4 From each of the pieces selected, one test specimen shall be taken for determining the various characteristics.

3.5 In case the lot is not in the form of bales or cases, but offered as pieces as such, the number of pieces to be selected at random from a lot for testing for a particular characteristics shall be equal to be number of tests required to be carried out according to **2**.

3.5.1 To ensure the randomness of selection of pieces the procedure as given in IS 4905:1968 'Methods for random sampling' shall be followed. The procedure for sampling shall be simple random sampling or systematic sampling as given in **3.1** or **3.3** respectively or IS 4905:1968 'Methods for random sampling'.

4 CRITERIA FOR CONFORMITY

4.1 For ascertaining the conformity of the lot to the specification requirements, the following procedure shall be adopted.

4.1.1 For any of the characteristics mentioned in **2.1.1**, all the test specimens subjected to the relevant test shall satisfy the requirements for that test.

4.1.2 *For Other Tests*

From the test results obtained on the test specimens selected according to **3**, the mean ($\bar{x}$) and the range (R) if the number of tests are less than 10, or the mean range ($\bar{R}$) if the number of tests are 10 or more, shall be calculated and the procedure given under **4.1.2.1** or **4.1.2.2** shall be followed to ascertain the conformity of the lot to the specified requirements.

4.1.2.1 *For one-sided specification limit*
The lot shall be declared as conforming to the specification if :

a) the value of the expression $(\bar{x} + kR)$ or $(\bar{x} + k\bar{R})$ is less than or equal to U, when the upper specification limit U is given;

OR

b) the value of the expression $(\bar{x} - kR)$ or $(\bar{x} - k\bar{R})$ is greater than or equal or L, when the lower specification limit L is given;

where the values of factor k are given in Table 3 for various sample sizes.

4.1.2.2 *For two-sided specification limit*
The lot shall be declared as conforming to the specification if:

a) the value of the expression $\frac{R}{U - L}$ or $\frac{R}{U - L} \leq B$,

b) the value of the expression $(\bar{x} + kR)$ or $(\bar{x} + k\bar{R}) \leq U$, and

c) the value of the expression $(\bar{x} - kR)$ or $(\bar{x} - k\bar{R}) \geq L$,

where the values of the factors B and k are given in Table 3 for different sample sizes, and U and L refer to the specification limits for the individual characteristics.

NOTE: The explanation of various symbols is given in Annex A.

Table 3 Values of the Factors
(*Clauses* 4.1.2.1 *and* 4.1.2.2)

Sample Size (n)	k	B
(1)	(2)	(3)
5 and 7	0.3	1.0
10	0.4	0.9
15 and above	0.5	0.8

5 ILLUSTRATIVE EXAMPLE

5.1 A seller delivers to a buyer a consignment consisting of 40 bales, of which 22 bales consist of long cloth and remaining 18 bales consist of poplin. The buyer desires to ascertain the conformity of the fabric supplied to the specification requirements of maximum 2.5 percent and 1.0 percent respectively with regard to shrinkage.

For the purpose of sampling and testing, the consignment shall be divided into two lots, one consisting of 22 bales of long cloth and other 18 bales of poplin. The procedure for selecting the sample and determining the conformity is explained below with reference to the first lot only; a similar procedure shall be followed in case of second lot also.

The number of bales to be chosen from a lot consisting of 22 bales shall be five according to Table 2. In order to select five bales at random from the lot, IS 4905:1968 'Methods for random sampling' shall be referred. Suppose, in this case, the numbers drawn are 3, 7, 13, 16, 20. Then, starting from any bale, the bales in the lot shall be counted in one order and the bales corresponding to above numbers shall be withdrawn from the lot for selecting pieces from them.

According to **2.2** and Table 1, ten tests corresponding to ten percent error shall be required for determination of shrinkage of the fabrics in the lot. Since the number of bales selected is five, two pieces of fabric shall be chosen from each bale for carrying out the tests.

Let the test results for warpway shrinkage (expressed as percentage) be as follows:

1 8, 2 3, 1 8, 1 7, 1 5, 1 8, 1.3, 1 8, 2 0, 2 0

The mean ($\bar{x}$) of the test results is obtained as:

$$\bar{x} = \frac{1\ 8 + 2\ 3 + \ldots\ldots\ldots + 2\ 0}{10} (18\ 0/10) = 1\ 80$$

The mean range ($\bar{R}$) of the test results shall be calculated by taking the ranges of the first five and last five test results. Thus,

$$\bar{R} = \frac{0\ 8 + 0\ 7}{2} = 0\ 75$$

Now the shrinkage has been specified as maximum 2.5 percent.

Hence according to **4.1.2.1** (a), it is found that the value of the expression ($\bar{x} + kR$) comes out to be (1 80 + 0 4 × 0 75) = 2 1, which is less than the upper specification limit of 2.5 percent.

Hence the lot consisting of long cloth shall be declared conforming to the specification requirement in respect of warpway shrinkage.

ANNEX A

(*Note under Clause* 4.1.2.2)

GLOSSARY OF SYMBOLS

$\bar{x}$ Mean; if x_1, x_2,.... ....x_n are the n measurements of the item in a sample, then $\bar{x} = \frac{x_1 + x_2 \ldots\ldots\ldots\ldots + x_n}{n}$

R Range; if x_1, x_2.......x_n are the n measurements of the items in sample, arranged in the ascending order of magnitude, then $R = x_n - x_1$.

R Mean Range; if R_1, R_2, ...R_m are the ranges of m subgroups of five observations each (so that sample size $n-5m$), then

$$\bar{R} = \frac{R_1 + R_2 \ldots\ldots + R_m}{m}$$

k Coefficient of R or $\bar{R}$ for the criteria for conformity.

B Maximum value for the expression $\frac{R}{U-L}$ or $\frac{\bar{R}}{U-L}$ in criteria for conformity for two-sided specification limits.

U Upper specification limit.

L Lower specification limit.

≤ Less than or equal to.

≥ Greater than or equal to.

SAMPLING OF WOOLEN FABRICS

(*Source* : IS 11191 : 1985)

1 SCOPE

It prescribes the methods of sampling of woollen fabrics for determination of various characteristics, namely, mass, breaking load (warp and weft), count of yarn, ends, picks, length, width, relaxation shrinkage, *p*H value of aqueous extract, proofing agent, colour fastness, DDT content, ether soluble matter and water penetration. It gives the number of tests for determination of breaking load and mass with specified degree of accuracy. It also lays down the criteria for ascertaining the conformity to the specified requirements for the characteristics.

2 SAMPLING

2.1 The pieces shall be sampled from each lot for determination of various characteristics. In order that pieces selected are representative of the lot, they shall be suitably distributed over the bales/ cases in the lot. Unless otherwise agreed to between the buyer and the seller, the number of bales/cases to be taken from a lot for the purpose shall depend upon the size of the lot and shall be in accordance with Table 1.

2.2 In case the lot is not in the form of bales or cases but offered as pieces or rolls, the number of pieces or rolls to be selected from the lot for testing shall be equal to the number of tests required to be carried out according to col 2 of Table 2.

Table 1 Number of Bales/Cases to be Chosen from a Lot

(*Clauses* 2.1, 3.4 *and* 5.1)

No. of Bales/Cases In the Lot	No. of Bales/Cases to be Selected
(1)	(2)
2 to 15	2
16 to 50	3
51 to 100	5
101 and above	10

2.3 The bales, cases, pieces or rolls shall be selected at random from the lot. The procedure for sampling shall be simple random sampling or systematic sampling as given in **3.1** and **3.3**, respectively of IS 4905:1968 'Methods for random sampling'.

3 NUMBER OF TESTS

3.1 The number of tests to be made for determination of the characteristics, namely, ends, picks, count of yarn, length, width, relaxation shrinkage, *p*H value of aqueous extract, proofing agent, colour fastness, DDT content, ether soluble matter and water penetration, shall be according to Table 2.

Table 2 Number of Tests for Ends, Picks, Count, Length, Width, Relaxation Shrinkage, *p*H Value of Aqueous Extract, Proofing Agent, Colour Fastness, DDT Content, Ether Soluble Matter and Water Penetration

(*Clauses* 2.2, 3.1, 3.4 *and* 5.1)

No. of Pieces in the Lot	Number of Tests for	
	Count, Ends, Pick, Length and Width	Relaxation Shrinkage, *p*H value of Aqueous Extract, Proofing Agent, Colour Fastness, DDT Content, Ether Soluble Matter and Water Penetration
(1)	(2)	(3)
Up to 150	8	3
151 to 500	13	5
501 to 1 000	20	8
1 001 and above	32	8

3.2 Number of tests to be made for determination of mass and breaking load (warp and weft) shall depend upon the accuracy with which they are to be determined, and are given in Table 3.

Table 3 Number of Tests for Mass and Breaking Load

(*Clause* 3.2)

Characteristic	Limit of Error of Mean (Percent)			
	5	6	8	10
Mass	10	7	5	3
Breaking load (Warp and Weft)	20	15	10	5

3.2.1 Unless otherwise agreed to between the supplier and the seller, five tests for mass and ten tests for breaking load (warp and weft) shall be taken for routine testing.

3.3 The number of tests for determination of count of yarn shall be the same as that for the mass.

3.4 As far as possible, equal number of pieces or rolls shall be drawn from each selected bale. The number of pieces or rolls taken from each bale shall be determined by dividing the number of tests to be conducted (*see* col 2 of Table 2) by the number of bales selected (*see* Table 1).

3.4.1 The number of pieces or rolls for determination of characteristics other than ends, picks, length and width shall be drawn from those which are already selected according to **2.2**. The number of pieces or rolls to be selected shall be the same as number of tests required to be carried out for the relevant characteristics except breaking load. In case of breaking load, the number of pieces or rolls to be selected shall be the same as that for mass.

4 CRITERIA FOR CONFORMITY

4.1 For ascertaining the conformity of the lot to the specification requirements for the characteristics given in **3.2** the procedure given in **4.1.1** and **4.1.2** shall be adopted. The procedure for determining the conformity of the lot is illustrated in examples in **5.1**.

4.1.1 *One-sided Specification Limit*
The lot shall be declared as conforming to the specification if:

a) the value of expression $(x - kR)$ or $(\bar{x} - k\bar{R})$ is greater than or equal to L, when the lower specification limit L is given,

or

b) the value of the expression $(\bar{x} + kR)$ or $(\bar{x} + k\bar{R})$ is less than or equal to U, when the upper specification limit U is given,

Where the values of the factor k are given in Table 4 for different sample sizes, and U and L refer to the specification limits for individual test results.

4.1.2 *Two-sided Specification Limit*
The lot shall be declared as conforming to the specification if:

a) the value of the expression $R/(U-L)$ or $\bar{R}/(U-L)$ is less than or equal to B,

b) the value of the expression $(x + kR)$ or $(\bar{x} + k\bar{R})$ is less than or equal to U, and

c) the value of the expression $(\bar{x} - kR)$ or $(\bar{x} - k\bar{R})$ is greater than or equal to L.

Where the values of the factors B and k are given in Table 4 for different sample sizes, and U and L refer to the specification limits for individual test results.

Table 4 Values of the Factors

(*Clauses* 4.1.1 *and* 4.1.2)

Sample Size	Factor	
n	k	B
(1)	(2)	(3)
3	0.5	0.9
5	0.4	0.9
7	0.4	1.0
10	0.5	0.8
15 and above	0.5	0.7

4.2 For ascertaining the conformity of the lot the specification requirements for the characteristics given in **3.1**, the following criteria for conformity shall be adopted.

4.2.1 The lot shall be declared conforming to the requirements of the specifications if the number of test results not meeting the requirements as laid down in the relevant specification does not exceed the corresponding acceptance number given in Table 5.

Table 5 Acceptance Numbers

Number of Tests	Acceptance Number
(1)	(2)
3	0
5	0
8	0
13	1
20	2
32	3

5 ILLUSTRATIVE EXAMPLE

5.1 A consignment of 75 bales of flannel, hospital grey was received by a buyer who wanted to ascertain the conformity of the lot to the requirement of breaking load for warp. The material was manufactured and supplied as per the requirements of IS 674:1987 'Flannel, hospital grey' which specifies a minimum 65 kg of breaking load on 15cm × 20cm strip for warp. The number of bales to be chosen from 75 bales according to Table 1 is 5.

If 6 percent limit of error of mean is chosen then according to **3.2** and Table 2, 15 tests are to be carried out. Hence following the procedure given in **3.4** (15/5) = 3 pieces or rolls are chosen from each of the selected bales. From each of the pieces thus selected, one test specimen shall be drawn and tested to determine the breaking load for warp in kg.

The observations obtained are as follows:

67	68	68	64	70
73	69	67	72	69
69	70	66	71	68

The mean of the test results is mean breaking load for

$$\text{warp } (\bar{x}) = \frac{67 + 68 + 68 \text{ ....} + 66 + 71 + 68}{15}$$

$$= \frac{1\,031}{15}$$

$$= 68.7$$

The mean range ($\bar{R}$) is calculated by taking the ranges of the three groups, each consisting of five consecutive test results.

Thus

$$\bar{R} = \frac{6 + 6 + 5}{3} = \frac{17}{3} = 5.7$$

Applying the criteria of **4.1.1** we have

$$\begin{aligned} \bar{x} - k\bar{R} &= 68.7 - 0.5 \times 5.7 \\ &= 68.7 - 2.9 \\ &= 65.8 \end{aligned}$$

Where the value of k is derived from Table 4.

Since, the criterion of **4.1.1** is satisfied, it is concluded that the lot meets the specification requirement of breaking load (warp).

SAMPLING OF MAN-MADE CONTINUOUS FILAMENT FLAT YARN

[*Source* : IS 7703 (Part 4) : 1981]

1 SCOPE

It prescribes the procedure for sampling of man-made fibre continuous filament polyster and polyamide flat yarn for determination of various physical characteristics, namely, linear density, tenacity, elongation at break evenness, broken filament and oil content. It gives the number of tests for determination of various characteristics with specified degree of accuracy. It also lays down the criteria for ascertaining the conformity of yarn to the specified requirements.

2 SAMPLING OF CONTINUOUS FILAMENT POLYESTER OR POLYAMIDE FLAT YARN

2.1 Unless otherwise agreed to between the buyer and the seller, the number of packages of continuous filament flat yarn to be taken from a lot shall be in accordance with Table 1.

2.2 The packages shall be selected at random from a lot.

2.2.1 When the sample is selected before the packages are packed in cases, the procedure of sampling shall be simple random sampling or systematic sampling as given in **3.1** or **3.3** respectively of IS 4905:1968 'Methods for random sampling'.

2.2.2 When the packages are to be selected from the cases, the procedure of sampling shall be two-stage sampling given in **3.5** of IS 4905:1968 'Methods for random sampling'.

Table 1 Number of Packages to be Chosen from a Lot

(*Clauses* 2.1, 2.3.2.1 *and* 4.1)

Number of Packages in the Lot (1)	Number of Packages to be Selected (2)
2 to 50	2
51 to 100	3
101 to 300	5
301 to 500	8
501 to 1 000	13
1 001 and above	20

2.3 NUMBER OF TESTS

2.3.1 The minimum number of test to be conducted for various characteristics shall depend upon the accuracy with which the characteristics are to be determined. Table 2 gives the number of tests necessary for determination of linear density, tenacity, elongation at break, evenness and oil content for varying limits of error. The probability level for number of tests given in Table 2 varies between 95 to 98 percent.

NOTE — The limit of error of mean is the maximum difference between the sample mean and its true value (that would be obtained if all the units in the lot were tested) at a given probability level.

Table 2 Number of Tests

(*Clauses* 2.3.1, 2.3.1.1 *and* 2.3.2.1)

Characteristic	Limit of Error of Mean, percent											
	1	1.5	2	3	4	5	7	10	11	13	15	20
Linear density	60	25	15	10	5	–	–	–	–	–	–	–
Tenacity	190	85	45	20	15	10	5	–	–	–	–	–
Elongation at break	–	210	120	50	30	20	10	5	–	–	–	–
Evenness	–	–	–	–	150	100	50	25	20	15	10	5
Oil content	190	85	45	20	15	10	5	–	–	–	–	–

2.3.1.1 For knowing the limit of error of mean corresponding to particular number of tests carried out for determination of a quality characteristics, Table 2 has been recast and given in Annex A with number of tests appearing in first column while the entries in subsequent columns give corresponding limit of error of mean for various quality characteristics. ,

2.3.2 Unless otherwise agreed to between the buyer and the seller, 20 tests for tenacity, elongation at break and 10 tests for linear density, evenness, and oil content shall be made.

2.3.2.1 As far as possible, equal number of test specimens shall be drawn from each package drawn according to **2.1** and **2.2**. The number of test specimens taken from each package shall be determined by dividing the number of tests to be conducted (*see* Table 2) by the number of packages selected (*see* Table 1). If it comes out to be a fractional number its maximum integral part (*say* i) shall be taken and i or $(i + 1)$ specimen shall be taken from each selected package so as to obtain the requisite number of test specimens. In case the number of tests are less than the number of packages selected, one or more test specimen may be drawn from each selected package to get the number of tests specimens or be an integral multiple of 5. For example, when there are 501 to 1 000 packages in the lot, 13 packages are selected for testing. According to **2.3.2** for routine testing, the number of tests for tenacity are 20 while they are 10 for linear density. For drawing test specimens for tenacity 20 test specimens are to be taken from 13 packages. Thus one (maximum integral part of 20/13) test specimen is taken out from each of 13 packages giving only 13 test specimens. The remaining 7 (= 20 − 13) test specimen are drawn one each from any 7 of the 13 packages. In case of linear density, the number of packages drawn (13) is greater than the number of test specimens (10) required. Hence instead of testing only 10 test specimens, 15 (the smallest integral multiple of 5 greater than 13) test specimens are tested. Here one test specimen is drawn from each of the 13 packages and the remaining 2 (=15−13) test specimens are drawn one each from any two of the 13 packages.

2.3.3 To determine the characteristics broken filament, each package in the sample, selected according to **2.3.2.1** shall be visually examined and number of broken filament counted

3 CRITERIA FOR CONFORMITY

3.1 For ascertaining the conformity of the lot to specification requirements, the procedure given in **3.1.1** or **3.1.2** shall be adopted. It may be noted that the criteria given in **3.1.1** and **3.1.2** is applicable when the specification limit refers to the individual test result and hence should not be applied in cases where specification limit is referring to average of the lot. The procedure for determining conformity of lot is illustrated in examples given in **4.1**.

3.1.1 *One-sided Specification Limit*

The lot shall be declared as conforming to the specification if:

a) the value of the expression $(\bar{x} - kR)$ or $(\bar{x} - k\bar{R})$ is greater than or equal to L, when the lower specification limit, L is given;

OR

b) the value of the expression $(\bar{x} + kR)$ or $(\bar{x} + k\bar{R})$ is less than or equal to U, when the upper specification limit U, is given.

Where the values of the factor k are given in Table 3 for different sample sizes, and U and L refer to the specification limits for individual test results.

NOTE— The explanation of various symbols is given in Annex B

3.1.2 *For Two-sided Specification Limit*

The lot shall be declared as conforming to the specification if:

a) the value of the expression $R/(U-L)$ or $\bar{R}/(U-L) \leq B$,

b) the value of the expression $(\bar{x} + kR)$ or $(\bar{x} + kR) \leq U$, and

c) the value of the expression $(\bar{x} - kR)$ or $(\bar{x} - k\bar{R}) \geq L$.

Where the values of the factors B and k are given in Table 3 for different sample sizes, and U and L refer to the specification limits for individual test results.

Table 3 Values of the Factors

(*Clauses* 3.1.1, 3.1.2 *and* 4.1)

Sample Size n	k	B
5	0.3	1.0
10	0.4	0.9
15 and above	0.5	0.8

3.2 In case of the quality characteristic broken filament, the lot shall be considered conforming to the specification requirements, if all the packages tested according to **2.3.3** meet the specification requirements.

4 ILLUSTRATIVE EXAMPLE

4.1 When Specification Limit Refers to Individual Test Result

A consignment of nylon yarn of 12/1 SD Designation containing 250 packages was delivered to a buyer. The buyer desires to ascertain the conformity of the lot to the requirement of linear density of 12 denier with tolerance of ± 5 percent.

The number of packages to be chosen according to Table 1 from the lot of 250 packages are 5 and the number of tests to be made for linear density according to **2.3.2** are 10.

Suppose, the packages are packed in 10 cases. Starting from any case and counting them in a predetermined order, we may select every alternative case; open the same, and select one package at random from each case.

Two test specimen of desired length shall be taken out and tested from each of the packages selected. The observations obtained in denier are as follows:

11.33	12.22	12.07	11.95	12.45
11.08	11.96	12.10	11.93	11.48

The mean of the test results shall be calculated as follows:

The mean liner density

$$(\bar{x}) = \frac{11\ 33 + 12\ 22 + \ldots + 11\ 93 + 11\ 48}{10}$$

$$= \frac{118 \cdot 57}{10}$$

$$= 11\ 857$$

$$\simeq 11\ 86$$

The mean range $\bar{R}$ of test results calculated by taking the ranges of two groups each consisting of five consecutive test results shall be:

$$R = \frac{1 \cdot 12 + 1 \cdot 02}{2} = \frac{2 \cdot 14}{2} = 1 \cdot 07$$

Applying the criteria given in **3.1.2**
We have

a) $\frac{R}{U - L} = \frac{1 \cdot 07}{1 \cdot 2} = 0 \cdot 89 \leq 0 \cdot 9\ (B)$

b) $\bar{X} + kR = 11\ 86 + 04 \times 1\ 07$
$= 11\ 86 + 0\ 43$
$12\ 29$
$\leq 12\ 60\ (U)$

c) $X + k\bar{R} = 11\ 86 - 0\ 43$
$= 11\ 43$
$\geq 11\ 40\ (L)$

Where, the values of B and k are given in Table 3.

Since, the criteria given under **3.1.2** is satisfied, we conclude that the lot meets the specification requirements.

NOTE — In case the specification limit refers to the average of the lot, the concepts or AQL, LQL, producer's risk and consumer's risk are not applicable as such However, the limit of error of mean given in Table 2 can be made use of for determining the conformity of the lot, as illustrated in example below (*see* **4.2**).

4.2 When Specification Limit Refers to Average of the Lot

A consignment of 40/10/0 nylon yarn containing 800 packages was delivered to a buyer who desires to ascertain the conformity of the lot to requirement of average tenacity of minimum 5.0 grams/denier.

The number of packages to be selected according to Table 1 from the lot of 800 packages are 13 and the number of tests to be made for tenacity according to **2.3.2** are 20.

Suppose, the packages in the sample are to be selected before they are packed in cases. The method given in **3.3** of IS 4905:1968 'Methods for random sampling' may be adopted for drawing the random sample. So, dividing 800 by 13 we get 61 as the maximum intergral part. Open any page, say 26 of IS 4905 : 1968 'Methods for random sampling' and choosing any row, say 293, we read the first 3 digits which are 071. Thus counting the packages in a predetermined order we select 71st, 132nd (= 71 + 61), 193rd (= 132 + 61), 254, 315, 376, 437, 498, 559, 620, 681, 742 and 3rd that is (742 + 61 = 803) package. To get 20 test specimen we draw one specimen from each of the 13 packages and the remaining 7 test specimen are drawn one each from any seven of the 13 packages and get tested for tenacity. The observations obtained are as follows:

5.3	5.3	5.0	5.2
5.4	5.4	5.2	5.1
4.9	5.2	5.4	5.0
5.0	5.2	5.4	5.1
4.9	5.3	4.8	4.9

The mean of the test results shall be calculated as follows:

$$\text{The mean tenacity} = \frac{5 \cdot 3 + 5 \cdot 4 + 4 \cdot 9 + \ldots\ldots + 5 \cdot 1 + 4 \cdot 9}{20}$$

$$g/d\ (\bar{x}) = \frac{103 \cdot 0}{20} = 5.15$$

From Table 2, we note that 20 tests correspond to 3 percent error of determination of mean. Thus, the observed average minus the error of determination, that is 5.00 *g*/*d* (= 5.15 – 0.15) is not less than the minimum specified value of 5.0 *g*/*d* and hence the lot is accepted as conforming.

ANNEX A

(*Clause* 2.3.1.1)

LIMIT OF ERROR OF MEAN CORRESPONDING TO DIFFERENT NUMBER OF TESTS FOR VARIOUS QUALITY CHARACTERISTICS

A-1 Table 4 gives the limit of error of mean corresponding to different number of test carried out for various quality characteristics. The probability level for the limit of error of mean given in Table 4 varies between 95 to 98 percent.

Table 4 Limit of Error of Mean

(*Clauses* 2.3.1.1 *and* A-1)

Number of Tests	Characteristics				
	Linear Density	Tenacity	Elongation at Break	Evenness	Oil Content
(1)	(2)	(3)	(4)	(5)	(6)
5	4	7	10	20	7
10	3	5	7	15	5
15	2	4	—	13	4
20	—	3	5	11	3
25	1.5	—	—	10	—
30	—	—	4	9	—
45	—	2	—	—	2
50	—	—	3	7	—
60	1.0	—	—	—	—
85	—	1.5	—	—	1.5
100	—	—	—	5	—
120	—	—	2	—	—
150	—	—	—	4	—
190	—	1	—	—	1
210	—	—	1.5	—	—

ANNEX B

(*Clause* 3.1.1)

GLOSSARY OF SYMBOLS

$\bar{x}$ Mean; if $x_1, x_2, \ldots\ldots x_n$ are the n measurements of the items in a sample

then $\bar{x} = \dfrac{x_1 + x_2 + \ldots\ldots + x_n}{n}$

R Range; if $x_1, x_2, \ldots\ldots x_n$ are the n measurements of items in a sample, arranged in the ascending order of magnitude, than $R = x_n - x_1$,

$\bar{R}$ Mean Range; if $R_1, R_2, \ldots\ldots R_m$ are the range of m subgroups of five observations each (so that the sample size $n = 5m$) then,

$$\bar{R} = \frac{R_1 + R_2 \ldots\ldots + R_m}{m}$$

k Coefficient of R or $\bar{R}$ for the criteria for conformity.

B Maximum value for the expression $\dfrac{R}{U-L}$ or $\dfrac{\bar{R}}{U-L}$ criteria for conformity for two-sided specification limits.

U Upper specification limit.

L Lower specification limit.

≤ Less than or equal to.

≥ Greater than or equal to.

PREPARATION OF TEST SPECIMENS FROM FABRIC SAMPLES FOR PHYSICAL TESTS

(*Source* : **IS 6668 : 1972**)

1 SCOPE

1.1 It prescribes procedure for preparing test specimens from fabric samples for the purpose of testing various physical characteristics.

1.1.1 This standard is applicable to all types of fabrics, namely, woven, knitted, felted and nonwoven, made from any type of fibre.

2 PROCEDURE

2.1 Woven Fabrics

2.1.1 Take one of the test samples drawn for the purpose of preparing test specimens, mark the warp and weft direction and lay it flat on the surface of smooth table. Remove any wrinkles or folds in the sample by hand without unduly stretching it.

2.1.2 Mark the required number of warpway and weftway test specimens of the required size from different portions of the sample under test. The length directions of the warpway and weftway test specimens shall be parallel to the warp and weft directions of the sample respectively. The specimens marked in each direction shall be scattered throughout the area of the sample (*see* Fig. 1A) in such a way that:

a) no two warpway specimens contain the same set of warp yarn, and
b) no two weftway specimens contain the same set of weft yarns.

2.1.2.1 However, in case it is not possible to have different sets of warp or weft yarns for different specimens, a portion of the warp or weft yarns taken in one specimen may be allowed to form a part of the other specimen (*see* Fig. 1B).

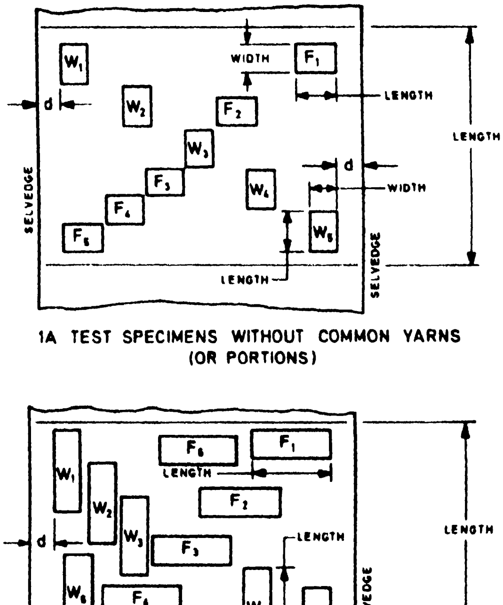
2.1.2.2 The number of test specimens to be drawn and the size of each specimen depends on the characteristic to be tested and shall be as laid down in the specification for the material or the method of test to be followed. In case there are more than one test sample for drawing test specimens, draw approximately equal number of specimens from each test sample to make up the total number of test specimens.

2.1.2.3 Avoid taking test specimens from the portions having wrinkles, folds or defects. Do not take any specimen within one-tenth of the fabric width from the selvedge. Mark the warpway and weftway test specimens with the letters '*W*' and '*F*' respectively for the purpose of identification.

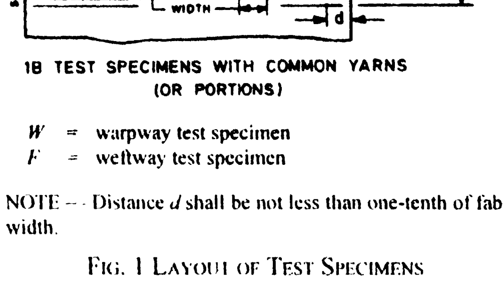
2.1.3 Cut with the help of a sharp razor or a pair of scissors the test specimens along the markings and collect the warpway and weftway specimens separately.

2.2 Other Fabrics

In the case of knitted, felted and nonwoven fabrics, the length and width directions should be treated as warp and weft directions respectively as in the case of woven fabrics and the test specimens prepared as above.



1A TEST SPECIMENS WITHOUT COMMON YARNS (OR PORTIONS)



1B TEST SPECIMENS WITH COMMON YARNS (OR PORTIONS)

W = warpway test specimen
F = weftway test specimen

NOTE — Distance *d* shall be not less than one-tenth of fabric width.

FIG. 1 LAYOUT OF TEST SPECIMENS

METHODS FOR PREPARATION OF LABORATORY TEST SAMPLES AND TEST SPECIMENS OF TEXTILE MATERIALS FOR CHEMICAL TESTING

(*Source* : IS 9022 : 1979)

This standard prescribes the methods in which the laboratory test samples are obtained by the combination of numerous small portions each drawn from a different part of the laboratory bulk sample. Therefore, any results obtained on test specimens from these samples will estimate the mean level in the laboratory bulk sample but will not indicate the variability of level from portion to portion of the laboratory bulk sample. Consequently it is appropriate to use this method in cases where it is desired to estimate the bulk composition, for example, the proportions of different fibres in a blend, but it is not appropriate in cases where variability is important, for example, in the determination of *p*H where the local value is significant, or in the determination of fungicides, where a high value in one area of the material does not compensate for low value elsewhere. Also, it may not be appropriate for use in determination of commercial mass values.

1 SCOPE

1.1 This method specifies procedure for laboratory test samples of textile materials from laboratory bulk samples taken from a bulk source and gives general directions for the preparation of test specimens of convenient size for chemical tests.

1.2 No provision for sampling from the bulk source is described since it is assumed that the laboratory bulk sample has been selected by a suitable procedure and is representative of the bulk source.

2 DEFINITIONS

For the purpose of this method, the following definitions shall apply.

2.1 Bulk Source

That quantity of material which is to be judged on the basis of one series of test results. This may comprise, for example, all the material in one delivery of cloth; all the cloth woven from a particular beam; a consignment of yarn; a bale or a group of bales of raw fibre.

2.2 Laboratory Bulk Sample

That portion of the bulk source taken to be representative of the whole. The size and nature of the laboratory bulk sample should be sufficient to overcome adequately the variability of the bulk source and to facilitate ease of handling in the laboratory.

2.3 Laboratory Test Sample

That portion of the laboratory bulk sample from which specimens are taken for testing. The size and nature of the laboratory test sample should be sufficient to overcome adequately the variability of the laboratory bulk sample.

2.4 Test Specimen

The portion of material required to give an individual test result.

3 PRINCIPLE

The laboratory test sample is taken so that it is representative of the laboratory bulk sample. The test specimens are taken from the laboratory test sample in such a way that each of them is representative of the laboratory test sample.

4 SAMPLING OF LOOSE FIBRES

4.1 Non-oriented Fibres

4.1.1 If the laboratory bulk sample consists of less than 5 kg of loose fibre, spread it out in an even layer. Obtain the laboratory test sample by taking at random a minimum of 100 tufts of approximately equal size, the total mass being sufficient to give a laboratory test sample of required size.

4.1.2 If the laboratory bulk sample is greater than 5 kg, divide it into a number of equal portions, and take an equal number of tufts of suitable mass from each portion such that the total number from all portions exceed 100.

4.1.3 Pretreat the laboratory test sample, if required, by the test method to be used. From the laboratory test sample remove at random, using forceps, small tufts of approximately equal mass to give a test specimen of the mass required.

4.2 Oriented Fibres (Card Webs, Slivers, Rovings)

From randomly selected parts of the laboratory bulk sample cut not less than ten cross sections each weighing approximately 1 g. After applying pretreatment, if necessary, lay the crosssections together and obtain the test specimen by cutting through them so as to take a portion of each of the ten lengths.

5 SAMPLING OF YARN

5.1 Yarn in Packages or in Hanks

5.1.1 If the number of packages in the laboratory bulk sample is 25 or less, sample all the packages. If the number exceeds 25, take 25 packages at random. If the linear density of the yarn, expressed in tex, is t, and the number of packages taken from the laboratory bulk sample is n, the length of yarn from each package to give a 10 g laboratory test sample is:

$$\frac{10^6}{n \times t} \text{ cm}$$

if $n \times t$ is high, for example, more than 2 000, wind a heavier skein and cut it across in two places to make a tow of suitable mass.

5.1.2 Withdraw the appropriate continuous length from each package either by winding skeins of the same number of turns on a warp reel (*see* Note) or by some other means. Unite the length side by side either as a single skein or as a tow to form the laboratory test sample, ensuring that there are equal lengths from each package in the skein or tow. Pretreat the laboratory test sample, if required, by a suitable method and ensure that the ends of any sample in the form of tow are securely tied before treatment.

NOTE — If the packages can be mounted in a convenient creel a sufficient number of skeins can be wound simultaneously.

5.1.3 Take specimens of the appropriate mass from the laboratory test sample by cutting a bunch of threads of equal length from the skein or tow and comprising all the threads in it, ensuring that test specimens are taken from a place remote from the tie bands.

5.2 Yarn on Warp

5.2.1 Take the laboratory test sample by cutting a length from the end of the warp, not less than 20 cm long and comprising all the yarns in the warp except the selvedge yarns, which are rejected. Tie the bunch of threads together near one end. If the sample is too large for any required pretreatment, divide it into two or more portions, each portion tied together separately for pretreatment. Reunite the portions after the pretreatment.

5.2.2 Take a test specimen by cutting a suitable length from the laboratory test sample from the end remote from the tie band, and comprising all the threads in the warp. For warp of N threads of tex t, the length of a specimen of mass 1 g is:

$$\frac{10^5}{N \times t} \text{ cm}$$

6 SAMPLING OF FABRIC

6.1 From a Laboratory Bulk Sample Consisting of a Single Cutting up to 1 m in Length

6.1.1 Cut a diagonal trip from corner to corner and remove the selvedges. For a laboratory test sample of X g the area of the strip required is:

$$\frac{X \times 10^4}{M} \text{ cm}^2$$

where M is the mass of the cloth in grams per square metre.

6.1.2 This area divided by the length of the diagonal in centimeters will give the required width of strip in centimeters.

6.1.3 After subjecting the strip to any pretreatment, cut it across its length into four equal lengths and superimpose them. Take test specimens from any part of the layered material by cutting through all the layers in such a way that each specimen comprises an equal length from each layer.

6.2 From a Laboratory Bulk Sample Consisting of a Single Cutting More than 1 m in Length

Take two full-width cuttings, one from each end of the laboratory bulk sample and not more than 1 m long. Cut both into two equal portions by a cut parallel to the warp direction and mark the right-hand and left-hand halves of each. Put the right-hand half of one cutting to the left-hand half of the other, with the cut edges together, and cut a diagonal strip from the lower corner of one cutting to the upper corner of the other, after removing the selvedges. Proceed as in **6.1**, treating the two half-width diagonal strips as if they were a full-width continuous strip.

6.3 From a Laboratory Bulk Sample Consisting of Several Cuttings

Treat each cutting separately as described in **6.1** or **6.2** and give results for each cutting in the test report.

6.4 From a Fabric with a Design Arising from the Distribution of Threads

6.4.1 Ensure, if possible, that there is an integral number of complete repeats of the design in the laboratory bulk sample and proceed as in **6.1** unless the laboratory bulk sample so obtained is more than 1 m in length in which case proceed as in **6.2**. Where the pattern repeat is large and/ or asymmetric, the entire strip should be cut into small fragments, thoroughly mixed and then sampled by the procedure indicated in **4.1**.

6.4.2 Where the laboratory bulk sample does not contain at least on complete repeat of the design, report this under **8.1** (b).

7 SAMPLING OF MADE-UP ARTICLES

7.1 The laboratory bulk sample normally consists of a complete made-up article or a representative part of such an article.

7.2 Determine whether all parts of the article are of similar composition; if so, treat the whole article as a laboratory bulk sample, and take a laboratory test sample representative of the laboratory bulk sample.

7.3 If parts of the article are of different composition, separate the parts and treat each as the laboratory bulk sample and take a laboratory test sample representative of the laboratory bulk sample.

8 TEST REPORT

8.1 The test report shall include the following information:

a) A statement that the material was sampled in accordance with this method,
b) The size of the laboratory bulk sample (*see also* **6.4.2**),
c) The size of the laboratory test sample, and
d) The size of the test specimen.

SECTION B

PHYSICAL TESTS

METHOD FOR CONDITIONING OF TEXTILES

(*Source* : IS 6359 : 1971)

Most of the textiles being hygroscopic in nature, the relative humidity and temperature of the atmosphere affect their physical and mechanical properties appreciably. In order that reliable comparisons may be made among different materials and products and among different laboratories, it is necessary to standardize the humidity and temperature conditions and the procedure by which the textile material may be brought to the moisture equilibrium before testing.

1 SCOPE

1.1 It prescribes procedure for conditioning of all textile materials.

1.1.1 This method also prescribes a procedure for pre-conditioning of textiles which would be necessary if specified in the standard test method or specification for the material under test before conditioning.

2 PRINCIPLE

The principle followed is to allow the textile material to remain in the conditioning room during its absorption cycle fòr a sufficient time to reach moisture equilibrium.

3 TERMINOLOGY

3.1 Atmospheric Conditions for Testing (Standard)

The atmosphere in which physical tests on textile materials are performed. It has a relative humidity of 65 ± 2 percent and temperature of 27 ± 20ºC.

3.2 Moisture Equilibrium

The condition reached by a sample or specimen in a controlled atmosphere when the net difference between the amount of moisture absorbed and the amount desorbed, as shown by a change in weight, shows no trend and becomes insignificant.

3.3 Moisture Equilibrium for Testing

The condition reached by sample or specimen during free exposure to moving air controlled at specified conditions. For test purposes, moisture equilibrium shall be reached by absorption, starting from a relatively low moisture content. Moisture equilibrium for testing is considered to have been reached when successive weighings carried out at intervals of not less than 2 hours of the textile materials freely exposed to the moving air differ by less than 0.25 percent.

3.4 Preconditioning

To bring a sample or specimen to a relatively low moisture content [equilibrium in an atmosphere between 10 and 25 percent RH and temperature not exceeding 50°C (*see* Note)] prior to conditioning in a controlled atmosphere for testing (while preconditioning in frequently translated as predrying, specimens should not, in fact, be brought to the over-dry state.).

NOTE – These conditions may be obtained by heating air at 65 percent RH and 27°C (the standard atmosphere) to a temperature up to 50° C in air circulating type oven

3.5 Relative Humidity

The ratio of the actual pressure of the water vapour in the atmosphere to the saturation vapour pressure at the same temperature. The ratio is usually expressed as a percentage.

NOTE - Under normal circumstances, the sling or whirling hygrometer or Assmann's are the most convenient instruments for measuring relative humidity, they are sufficiently accurate for this purpose.

4 APPARATUS

4.1 Conditioning Room or Chamber

Equipped with apparatus capable of maintaining standard atmosphere for conditioning and testing throughout the room or chamber within the specified tolerances of relative humidity and temperature and having arrangements for maintenance of proper air circulation (*see* **3.1**).

4.1.1 It shall also be equipped with the instruments for recording relative humidity and temperature.

4.2 Preconditioning Cabinet or Room

Equipped with apparatus capable of maintaining atmosphere for pre-conditioning of textiles throughout the room or chamber within the specified tolerances of relative humidity and temperature (*see* **3.4**)

4.3 Balance

Capable of weighing to an accuracy of 0.25 percent.

5 PROCEDURE

5.1 Determine the relative humidity and temperature of the conditioning room or chamber (*see* **4.1**) and, if preconditioning is also to be carried out, find the relative humidity and temperature of the preconditioning cabinet or room to check whether the conditions meet the specified values of relative humidity and temperature or not If the conditions are not as required, make adjustments to bring them to the desired limits of temperature and humidity

5.1.1 If both preconditioning and conditioning are prescribed in the test method or the specification for the material, proceed as gives in **5.2** and **5.3**, and if only conditioning has been prescribed, omit **5.2**.

5.2 Expose the specimen or sample in the atmosphere for preconditioning in such a way as to expose, as far as possible, all portions of the material to the atmosphere until the moisture equilibrium is attained (*see* Note 1 under **5.3**).

5.3 Expose the specimen or sample (already preconditioned, if so required) in the standard atmosphere in such a way as to expose, as far as possible, all portions of the material to the atmosphere until the moisture equilibrium is attained (*see* Notes).

NOTES

1 In case the material received is in package form, it is preferable to prepare test specimens in loose or open form so that all portions get uniformly exposed to the preconditioning or conditioning atmospheres For example, in case of yarn in the form of cones or cheeses, suitable skeins may be prepared for conditioning

2 For guidance purposes, it may be noted that the minimum time required for the various types of textile materials having moisture regain values of less than 5 percent is about 6 hours to reach moisture equilibrium while for those having moisture regain values of more than 5 percent it is 24 hours

5.4 The textile materials conditioned as above be tested according to the procedure laid down.

CONVERSION FACTORS AND CONVERSION TABLES FOR YARN COUNTS

(*Source* : IS 3689 : 1966)

1 SCOPE

If defines the various count systems and provides factors and formulae for inter-conversion of yarn counts. Tables for inter-conversion of values in traditional count systems and Tex System are also included.

2 DEFINITIONS

2.1 Direct System

The count system in which the size of the yarn is expressed in terms of the mass of yarn per unit length.

2.2 Indirect System

The count system in which the size of the yarn is expressed in terms of the length of yarn per unit mass.

3 CONVERSION FACTORS

Table 1 Conversion Factors for Direct Systems and Tex

Sl No.	Yarn Count System	Symbolic Abbre-viation	Unit of Mass Used	Unit of Length Used	Unit of Yarn Count	Conversion Factors	
						To Other Yarn Counts from Tex	To Tex from Other Yarn Counts
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Tex	T_t	1g	1 000m	g/1 000m	—	—
ii)	Denier	T_d	1g	9 000m	g/9 000m	$T_d = 9T_t$	$T_t = 0.111\,1\ T_d$
iii)	Grist [Jute, Hemp, Linen (dry spun)]	Tj	1 lb	14 400yd (Spyndle unit)	lb/14 400 yd	$T_j = 0.029\,03\ T_t$	$T_t = 34.45\ T_j$

Table 2 Conversion Factors for Indirect Systems and Tex

Sl No.	Yarn Count System	Symbolic Abbreviation	Unit of Length Used	Unit of Mass Used	Unit of Yarn Count	Conversion Factors	
						To Other Yarn Counts from Tex	To Tex from Other Yarn Counts
i)	Cotton count (Spunrayon staple, spun silk)	N_eC (hank)	840yd (hank)	1 lb	840 yd/lb	$N_eC = \frac{590\cdot5}{T_t}$	$T_t = \frac{590\cdot5}{N_eC}$
ii)	Liner (wet spun)	N_eL	300 yd (lea)	1 lb	300 yd/lb	$N_eL = \frac{1\cdot654}{T_t}$	$T_t = \frac{1\,654}{N_eL}$
iii)	Metric (cotton and wool)	N_m	1 000m (hank)	1 kg	1 000 m/kg	$N_m = \frac{1000}{T_t}$	$T_t = \frac{1\,000}{N_m}$
iv)	Woollen (Dewsbury)	N_d	1 yd	1 oz	yd/oz	$N_d = \frac{31000}{T_t}$	$T_t = \frac{31\,000}{N_d}$
v)	Woollen (Yorkshire)	N_y	256 yd (Skein)	1 lb	256 yd/1b	$N_y \frac{1\,938}{T_t}$	$T_t \frac{1\,938}{T_t}$
vi)	Worsted	N_eW	560 yd (hank)	1 lb	560 yd/lb	$N_eW = \frac{885\cdot8}{T_t}$	$T_t = \frac{885\cdot8}{N_eW}$

Table 3 Conversion Formulae for Inter-Conversion of Yarn Counts

Yarn Counts	Tex (T_t)	Denier (T_d)	Grist [Jute, Linen (Dry Spun), Hemp] (T_j)	Cotton Count (Spun-Rayon Staple, Spun Silk) (N_eC)	Linen (Wet Spun) (N_eL)	Metric (N_m)	Woollen (Dewsbury) (N_d)	Woollen (Yorkshire) (N_y)	Worsted (N_eW)
	(Direct to Direct System)			*(Direct to Indirect System)*					
Tex (T)	T	$T_d = 9 \times T_t$	$T_j = 0.290\,03 \cdot T$	$N_eC = \frac{590.5}{T_t}$	$N_eL = \frac{1654}{T}$	$N_m = \frac{1000}{T_t}$	$N_d = \frac{31\,000}{T_t}$	$N_y = \frac{1938}{T_t}$	$N_eW = \frac{885.8}{T_t}$
Denier (T_d)	$T_t = 0.1111 \cdot T_d$	T_d	$T_j = 0.003225 \times T_d$	$N_eC = \frac{5315}{N_d}$	$N_eL = \frac{14\,880}{T_d}$	$N_m = \frac{9000}{T_d}$	$N_d = \frac{279\,000}{T_d}$	$N_y = \frac{17\,440}{T_d}$	$N_eW = \frac{7972}{T_d}$
Grist [Jute, (dry spun), Hemp] (T_j)	$T_t = 34.45 \times T_j$	$T_d = 310 \times T_j$	$T_j =$	$N_eC = \frac{17.14}{T_j}$	$N_eL = \frac{48.00}{T_j}$	$N_m = \frac{29.03}{T_j}$	$N_d = \frac{899.9}{T_j}$	$N_y = \frac{56.25}{T_j}$	$N_eW = \frac{25.71}{T_j}$
	(Indirect to Direct System)			*(Indirect to Indirect System)*					
Cotton Count (spun-rayon silk) (N_eC)	$T = \frac{590.5}{N_ec}$	$T_d = \frac{5315}{N_eC}$	$T_j = \frac{17.14}{N_eC}$	N_eC	$N_eL = 2.80 \times N_eC$	$N_m = 1.693 \times N_eC$	$N_d = 52.50 \times N_eC$	$N_y = 3.281 \times N_eC$	$N_eW = 1.50 \times N_eC$
Linen (wet spun) (N_eL)	$T = \frac{1654}{N_eL}$	$T_d = \frac{14\,880}{N_eL}$	$T_j = \frac{48.00}{N_eL}$	$N_eC = 0.3571 \times N_eL$	N_eL	$N_m = 0.6048 \times N_eL$	$N_d = 18.74 \times N_eL$	$N_y = 1.172 \times N_eL$	$N_eW = 0\ 535.7 \times N_eC$
Metric (N_m)	$T_t = \frac{1000}{N_m}$	$T_d = \frac{9000}{N_m}$	$T_j = \frac{29.03}{N_m}$	$N_eC = 0.5905 \times N_m$	$N_eL = 1.654 \times N_m$	N_m	$N_d = 31.00 \times N_m$	$N_y = 1.938 \times N_m$	$N_eW = 0.885 \times N_m$
Woollen (Dewsburry) (N_d)	$T_t = \frac{31\,000}{N_d}$	$T_d = \frac{279\,000}{N_d}$	$T_j = \frac{899.9}{N_d}$	$N_eC = 0.01905 \times N_d$	$N_eL = 0.05335 \times N_d$	$N_m = 0.03226 \times N_d$	N_d	$N_y = 0.06252 \times N_d$	$N_eW = 0.02857 \times N_d$
Woollen (Yorkshire) (N_y)	$T_t = \frac{1938}{N_y}$	$T_d = \frac{17\,440}{N_y}$	$T_j = \frac{56.25}{N}$	$N_eC = 0.3048 \times N_y$	$N_eL = 0.8533 \times N_y$	$N_m = 0.5161 \times N_y$	$N_d = 16.00 \times N_y$	N_y	$N_ew = 0.4571 \times N_y$
Worsted (N_ew)	$T_t = \frac{885.8}{N_ew}$	$T_d = \frac{7972}{N_eW}$	$T_j = \frac{25.71}{N_ew}$	$N_eC = 0.6667 \times N_eW$	$N_eL = 1.867 \times N_eW$	$N_m = 1.129 \times N_eW$	$N_d = 35.00 \times N_eW$	$N_y = 2.188 \times N_eW$	N_eW

Table 4 Cotton Count (Spun-Rayon Staple, Spun Silk) (N_eC) to Tex (T_t)

$$\text{Tex} = \frac{590.5}{\text{Cotton Count}}$$

Cotton Count	0	1	2	3	4	5	6	7	8	9
	Tex	Tex	Tex	Tex	Tex	Tex	Tex	Tex	Tex	Tex
0	0	590.5	295.3	196.8	147.6	118.1	98.4	84.4	73.8	65.6
10	59.0	53.7	49.2	45.4	42.2	39.9	36.9	34.7	32.8	31.1
20	29.5	28.1	26.8	25.7	24.6	23.6	22.7	21.9	21.1	20.4
30	19.7	19.0	18.4	17.9	17.4	16.9	16.4	16.0	15.5	15.1
40	14.8	14.4	14.1	13.7	13.4	13.1	12.8	12.6	12.3	12.1
50	11.8	11.6	11.4	11.1	10.9	10.7	10.5	10.4	10.2	10.0
60	9.84	9.68	9.52	9.37	9.23	9.09	8.95	8.81	8.68	8.56
70	8.44	8.32	8.20	8.09	7.98	7.87	7.77	7.67	7.57	7.48
80	7.38	7.29	7.20	7.11	7.03	6.95	6.87	6.79	6.71	6.64
90	6.56	6.49	6.42	6.35	6.28	6.22	6.15	6.09	6.03	5.96
100	5.91	5.85	5.79	5.73	5.68	5.62	5.57	5.52	5.47	5.42
110	5.37	5.32	5.27	5.23	5.18	5.14	5.09	5.05	5.00	4.96
120	4.92									

Table 5 Denier (T_d) to Tex (T_t)

Tex = 0.1111 × Denier

Denier	0	1	2	3	4	5	6	7	8	9
	Tex	Tex	Tex	Tex	Tex	Tex	Tex	Tex	Tex	Tex
0	0	0.111	0.222	0.333	0.444	0.556	0.667	0.778	0.889	1.00
10	1.11	1.22	1.33	1.44	1.56	1.67	1.78	1.89	2.00	2.11
20	2.22	2.33	2.44	2.56	2.67	2.78	2.89	3.00	3.11	3.22
30	3.33	3.44	3.56	3.67	3.78	3.89	4.00	4.11	4.22	4.33
40	4.44	4.56	4.67	4.78	4.89	5.00	5.11	5.22	5.33	5.44
50	5.56	5.67	5.78	5.89	6.00	6.11	6.22	6.33	6.44	6.56
60	6.67	6.78	6.89	7.00	7.11	7.22	7.33	7.44	7.56	7.67
70	7.78	7.89	8.00	8.11	8.22	8.33	8.44	8.56	8.67	8.78
80	8.89	9.00	9.11	9.22	9.33	9.44	9.56	9.67	9.78	9.89
90	10.0	10.1	10.2	10.3	10.4	10.6	10.7	10.8	10.9	11.0
100	11.1									

Table 6 Grist (T_l) to Tex (T_t)

Tex = 34.45 × Grist

Grist	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
	Tex	Tex	Tex	Tex	Tex	Tex	Tex	Tex	Tex	Tex
0	0	17.2	34.4	51.7	68.9	86.1	103.3	120.6	137.8	155.0
5	172.2	189.4	206.7	223.9	241.1	258.4	275.6	292.8	310.0	327.3
10	344.5	361.7	378.9	396.1	413.3	430.6	447.8	465.0	482.3	500.0
15	516.7	534.0	551.2	568.4	585.6	602.8	620.1	637.3	654.5	671.7
20	689.0	706.2	723.4	740.6	757.9	775.1	792.3	809.5	826.8	844.0
25	861.2	878.4	895.6	912.8	930.1	947.3	964.6	981.8	999.0	1 016.2
30	1 033									

Table 7 Linen Count (N_eL) to Tex (T_t)

$$\text{Tex} = \frac{1\,654}{\text{Linen Count}}$$

Linen Count	0	1	2	3	4	5	6	7	8	9
	Tex	Tex	Tex	Tex	Tex	Tex	Tex	Tex	Tex	Tex
0	0	1 654	826.8	551.2	413.4	330.7	275.6	236.2	206.7	183.7
10	165.4	150.3	137.8	127.2	118.1	110.2	103.3	97.3	91.9	87.0
20	82.7	78.7	75.2	71.9	68.9	66.1	63.6	61.2	59.1	57.0
30	55.1	53.3	51.7	50.1	48.6	47.2	45.9	44.7	43.5	42.4
40	41.3	40.3	39.4	38.5	37.6	36.7	35.9	35.2	34.4	33.7
50	33.1	32.4	31.8	31.2	30.6	30.1	29.5	29.0	28.5	28.0
60	27.6	27.1	26.7	26.2	25.8	25.4	25.1	24.7	24.3	24.0
70	23.6	23.3	23.0	22.7	22.3	22.0	21.8	21.5	21.2	20.9
80	20.7	20.4	20.2	19.9	19.7	19.5	19.2	19.0	18.8	18.6
90	18.4	18.2	18.0	17.8	17.6	17.4	17.2	17.0	16.9	16.7
100	16.5	16.4	16.2	16.1	15.9	15.7	15.6	15.5	15.3	15.2
110	15.0	14.9	14.8	14.6	14.5	14.4	14.3	14.1	14.0	13.9
120	13.8									

Table 8 Metric Count (N_m) to Tex (T_t)

$$\text{Tex} = \frac{1\,000}{\text{Metric Count}}$$

Metric Count	0	1	2	3	4	5	6	7	8	9
	Tex	Tex	Tex	Tex	Tex	Tex	Tex	Tex	Tex	Tex
0	0	1 000	500 0	333 3	250 0	200 0	166 7	142 8	125 0	111 1
10	100 0	90 9	83 3	76 9	71 4	66 7	62 5	58 8	55 6	52 6
20	50 0	47 6	45 4	43 5	41 7	40 0	38 5	37 0	35 7	34 5
30	33 3	32 3	31 2	30 3	29 4	28 6	27 8	27 0	26 3	25 6
40	25 0	24 4	23 8	23 3	22 7	22 2	21 7	21 3	20 8	20 4
50	20 0	19 6	19 2	18 9	18 5	18 2	17 9	17 5	17 2	17 0
60	16 7	16 4	16 1	15 9	15 6	15 4	15 2	14 9	14 7	14 5
70	14 3	14 1	13 9	13 7	13 5	13 3	13 2	13 0	12 8	12 7
80	12 5	12 3	12 2	12 0	11 9	11 8	11 6	11 5	11 4	11 2
90	11 1	11 0	10 9	10 8	10 6	10 5	10 4	10 3	10 2	10 1
100	10 0									

Table 9 Woollen (Dewsbury) (N_d) to Tex (T_t)

$$\text{Tex} = \frac{31\,000}{\text{Woollen Count (Dewsbury)}}$$

Woollen Count	0	1	2	3	4	5	6	7	8	9
	Tex	Tex	Tex	Tex	Tex	Tex	Tex	Tex	Tex	Tex
0	0	31 000	15 500	10 333	7 750	6 200	5 167	4 428	3 875	3 444
10	3 100	2 818	2 583	2 385	2 214	2 067	1 938	1 824	1 722	1 632
20	1 550	1 476	1 409	1 348	1 292	1 240	1 192	1 148	1 107	1 069
30	1 033	1 000	968 8	939 4	911 8	885 7	861 1	837 8	815 8	794 9
40	775 0	756 1	738 1	720 9	704 5	688 9	673 9	659 6	645 8	632 6
50	620 0	607 8	596 2	584 9	574 1	563 6	553 6	543 8	534 5	525 4
60	516 7	508 2	500 0	492 1	484 4	476 9	469 7	462 7	455 9	449 3
70	442 8	436 6	430 6	424 6	418 9	413 3	407 9	402 6	397 4	392 4
80	387 5	382 7	378 0	373 5	369 0	364 7	360 5	356 3	352 3	348 3
90	344 4	340 6	337 0	333 3	329 8	326 3	322 9	319 6	316 3	313 1
100	310 0									

Table 10 Woollen (Yorkshire) (N_y) to Tex (T_t)

$$\text{Tex} = \frac{1\ 938}{\text{Woollen Count (Yorkshire)}}$$

Woollen Count	0	1	2	3	4	5	6	7	8	9
	Tex	Tex	Tex	Tex	Tex	Tex	Tex	Tex	Tex	Tex
0	0	1 938	968·9	645·9	484·4	387·5	323·0	276·8	242·2	215·3
10	193·8	176·2	161·5	149·1	138·4	129·2	121·1	114·0	107·6	102·0
20	96·9	92·3	88·1	84·2	80·7	77·5	74·5	71·8	69·2	66·8
30	64·6	62·5	60·6	58·7	56·9	55·4	53·8	52·4	50·9	49·7
40	48·4	47·3	46·1	45·1	44·0	43·1	42·1	41·2	40·4	39·5
50	38·8	37·9	37·3	36·6	35·9	35·2	34·6	33·9	33·4	32·8
60	32·3									

Table 11 Worsted (N_eW) to Tex (T_t)

$$\text{Tex} = \frac{885 \cdot 8}{\text{Worsted Count}}$$

Worsted Count	0	1	2	3	4	5	6	7	8	9
	Tex	Tex	Tex	Tex	Tex	Tex	Tex	Tex	Tex	Tex
0	0	885·8	442·9	295·3	221·5	177·2	147·6	126·5	110·7	98·4
10	88·6	80·5	73·8	68·1	63·3	59·1	55·4	52·1	49·2	46·6
20	44·3	42·2	40·3	38·5	36·9	35·4	34·1	32·8	31·6	30·6
30	29·5	28·6	27·7	26·8	26·0	25·3	24·6	23·9	23·3	22·7
40	22·1	21·6	21·1	20·6	20·1	19·7	19·3	18·8	18·5	18·1
50	17·7	17·4	17·0	16·7	16·4	16·1	15·8	15·5	15·3	15·0
60	14·8	14·5	14·3	14·1	13·8	13·6	13·4	13·2	13·0	12·8
70	12·6	12·5	12·3	12·1	12·0	11·8	11·7	11·5	11·4	11·2
80	11·1									

Table 12 Tex to Other Count Systems

Tex (T_t) (1)	Cotton Count (N_eC) (2)	Denier (T_d) (3)	Grist (T_l) (4)	Linen (N_eL) (5)	Metric (N_m) (6)	Woollen (Dewsbury) (N_d) (7)	Woollen (Yorkshire) (N_y) (8)	Worsted (N_eW) (9)
1	590 5	9 00	0 029	1 654	1 000	31 000	1 938	885 8
2	295 2	18 0	0 058	826 8	500 0	15 500	968 9	442 9
3	196 8	27 0	0 087	551 2	333 3	10 333	645 9	295 3
4	147 6	36 0	0 116	413 4	250 0	7 750	484 4	221 5
5	118 1	45 0	0 145	330 7	200 0	6 200	387 5	177 2
6	98 4	54 0	0 174	275 6	166 7	5 167	323 0	147 6
7	84 4	63 0	0 203	236 2	142 9	4 428	276 8	126 5
8	73 8	72 0	0 232	206 7	125 0	3 875	242 2	110 7
9	65 6	81 0	0 261	183 7	111 1	3 444	215 3	98 5
10	59 0	90 0	0 290	165 4	100 0	3 100	193 8	88 6
11	53 7	99 0	0 319	150 3	90 9	2 818	176 2	80 5
12	49 2	108 0	0 348	137 8	83 3	2 583	161 5	73 8
13	45 4	117 0	0 377	127 2	76 9	2 385	149 1	68 1
14	42 2	126 0	0 406	118 1	71 4	2 214	138 4	63 3
15	39 4	135 0	0 435	110 2	66 6	2 067	129 2	59 0
16	36 9	144 0	0 464	103 3	62 5	1 938	121 1	55 4
17	34 7	153 0	0 494	97 3	58 8	1 824	114 0	52 1
18	32 8	162 0	0 523	91 9	55 5	1 722	107 7	49 2
19	31 1	171 0	0 552	87 0	52 6	1 632	102 0	46 6
20	29 5	180 0	0 581	82 7	50 0	1 550	96 9	44 3
21	28 1	189 0	0 610	78 7	47 6	1 476	92 3	42 2
22	26 8	198 0	0 639	75 2	45 4	1 409	88 1	40 3
23	25·7	207 0	0 668	71 9	43 5	1 348	84 2	38 5
24	24 6	216 0	0 697	68 9	41 7	1 292	80 7	36 9
25	23 6	225 0	0 726	66 1	40 0	1 240	77 5	35 4
26	22 7	234 0	0 755	63 6	38 5	1 192	74 5	34 1
27	21 9	243 0	0 784	61 2	37 0	1 148	71 8	32 8
28	21 1	252 0	0 813	59 1	25 7	1 107	69 2	31 6
29	20 4	361 0	0 842	57 0	34 5	1 069	66 8	30 6
30	19 7	270 0	0 871	55 1	33 3	1 033	64 6	29 5
31	19 0	279 0	0 900	53 3	32 3	1 000	62 5	28 6
32	18 4	288 0	0 929	51 7	31 2	968 8	60 6	27 7
33	17 9	297 0	0 958	50 1	30 3	939 4	58 7	26 8
34	17 4	306 0	0 987	48 6	29 4	921 8	56 9	26 0
35	16 9	315 0	1 02	47 2	28 6	885 7	55 4	25 3
36	16 4	324 0	1 04	45 9	27 8	861 1	53 8	24 6
37	16 0	333 0	1 07	44 7	27 0	837 8	52 4	23 9
38	15 5	342 0	1 10	43 5	26 3	815 8	50 9	23 3
39	15 1	351 0	1 13	42 4	25 6	794 9	49 7	22 7
40	14 8	360 0	1 16	41 3	25 0	775 0	48 4	22 2
41	14 4	369 0	1 19	40 3	24 4	756 1	47 3	21 6
42	14 1	378 0	1 22	39 4	23 8	738 1	46 1	21 1
43	13 7	387 0	1 25	38 5	23 2	720 9	45 1	20 6
44	13 4	396 0	1 28	37 6	22 7	704 5	44 0	20 1
45	13 1	405 0	1 31	36 7	22 2	688 9	43 1	19 7

Table 12 Tex to Other Count Systems — *Contd*

Tex (*T*) (1)	Cotton Count (N_eC) (2)	Denier (T_d) (3)	Grist (T_l) (4)	Linen (N_eL) (5)	Metric (N_m) (6)	Woollen (Dewsbury) (N_d) (7)	Woollen (Yorkshire) (N_y) (8)	Worsted (N_eW) (9)
46	12.8	414.0	1.34	35.9	21.7	673.9	42.1	19.3
47	12.6	423.0	1.36	35.2	21.3	659.6	41.2	18.8
48	12.3	432.0	1.39	34.4	20.8	645.8	40.4	18.4
49	12.0	441.0	1.42	33.7	20.4	632.6	39.5	18.1
50	11.8	450.0	1.45	33.1	20.0	620.0	38.8	17.7
51	11.6	459.0	1.48	32.4	19.6	607.8	37.9	17.4
52	11.4	468.0	1.51	31.8	19.2	596.2	37.3	17.0
53	11.1	477.0	1.54	31.2	18.9	584.9	36.6	16.7
54	10.9	486.0	1.57	30.6	18.5	574.1	35.9	16.4
55	10.7	495.0	1.60	30.1	18.2	563.6	35.2	16.1
56	10.5	504.0	1.63	29.5	17.8	553.6	34.6	15.8
57	10.4	513.0	1.65	29.0	17.5	543.8	33.9	15.5
58	10.2	522.0	1.68	28.5	17.2	534.5	33.4	15.3
59	10.0	531.0	1.71	28.0	16.9	525.4	32.8	15.0
60	9.84	540.0	1.74	27.6	16.6	516.7	32.3	14.8
61	9.68	549.0	1.77	27.1	16.4	508.2	31.8	14.5
62	9.52	558.0	1.80	26.7	16.1	500.0	31.3	14.3
63	9.37	567.0	1.83	26.2	15.9	492.1	30.8	14.1
64	9.23	576.0	1.86	25.8	15.6	484.4	30.3	13.8
65	9.09	585.0	1.89	25.4	15.4	476.9	29.8	13.6
66	8.95	594.0	1.92	25.1	15.2	469.7	29.4	13.4
67	8.81	603.0	1.94	24.7	14.9	462.7	28.9	13.2
68	8.68	612.0	1.97	24.3	14.7	455.9	28.5	13.0
69	8.56	621.0	2.00	24.0	14.5	449.3	28.1	12.8
70	8.44	630.0	2.03	23.6	14.3	442.8	27.7	12.6
71	8.32	639.0	2.06	23.3	14.1	436.6	27.3	12.5
72	8.20	648.0	2.09	23.0	13.9	430.6	26.9	12.3
73	8.09	657.0	2.12	22.7	13.7	424.6	26.5	12.1
74	7.98	666.0	2.15	22.3	13.5	418.9	26.2	11.9
75	7.87	675.0	2.18	22.0	13.3	413.3	25.8	11.8
76	7.77	684.0	2.21	21.8	13.2	407.9	25.5	11.7
77	7.67	693.0	2.24	21.5	13.0	402.6	25.2	11.5
78	7.57	702.0	2.26	21.2	12.8	392.4	24.8	11.4
79	7.48	711.0	2.29	20.9	12.6	393.4	24.5	11.2
80	7.38	720.0	2.32	20.7	12.5	387.5	24.2	11.1
81	7.29	729.0	2.35	20.4	12.3	382.7	23.9	10.9
82	7.20	738.0	2.38	20.2	12.2	378.0	23.6	10.8
83	7.11	747.0	2.41	19.9	12.0	373.5	23.3	10.7
84	7.03	756.0	2.44	19.7	11.9	369.0	23.1	10.5
85	6.95	765.0	2.47	19.5	11.8	364.7	22.8	10.4
86	6.87	774.0	2.50	19.2	11.6	360.5	22.5	10.3
87	6.79	783.0	2.53	19.0	11.5	356.3	22.3	10.2
88	6.71	792.0	2.55	18.8	11.4	352.3	22.0	10.1
89	6.64	801.0	2.58	18.6	11.2	348.3	21.8	10.0
90	6.56	810.0	2.61	18.4	11.1	344.4	21.5	9.84

Table 12 Tex to Other Count Systems — *Contd*

Tex	Cotton Count	Denier	Grist	Linen	Metric	Woollen (Dewsbury)	Woollen (Yorkshire)	Worsted
(T_t)	(N_eC)	(T_d)	(T_j)	(N_eL)	(N_m)	(N_d)	(N_y)	(N_eW)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
91	6 49	819 0	2 64	18 2	11 0	340 6	21 3	9 73
92	6 42	828 0	2 67	18 0	10 9	337 0	21 1	9 63
93	6 35	837 0	2 70	17 8	10 8	333 3	20 8	9 52
94	6 28	846 0	2 73	17 6	10 6	329 8	20 6	9 42
95	6 22	855 0	2 76	17 4	10 5	326 3	20 4	9 32
96	6 15	864 0	2 79	17 2	10 4	322 9	20 2	9 23
97	6 09	873 0	2 82	17 0	10 3	319 6	20 0	9 13
98	6 03	882 0	2 84	16 9	10 2	316 3	19 8	9 04
99	5 97	891 0	2 87	16 7	10 1	313 1	19 6	8 95
100	5 91	900 0	2 90	16 5	10 0	310 0	19 4	8 86
105	5 62	945 0	3 05	15 7	9 52	295 2	18 5	8 44
110	5 37	990 0	3 19	15 0	9 09	281 8	17 6	8 05
115	5 14	1 035	3 34	14 4	8 70	269 6	16 9	7 70
120	4 92	1 080	3 48	13 8	8 33	258 3	16 1	7 38
125	4 72	1 125	3 63	13 2	8 00	248 0	15 5	7 09
130	4 54	1 170	3 77	12 7	7 69	238 5	14 9	6 81
135	4 37	1 215	3 92	12 2	7 41	229 6	14 4	6 56
140	4 22	1 260	4 06	11 8	7 14	221 4	13 8	6 33
145	4 07	1 305	4 21	11 4	6 90	213 8	13 4	6 11
150	3 94	1 350	4 35	11 0	6 66	206 7	12 9	5 90
155	3 81	1 395	4 50	10 7	6 45	200 0	12 5	5 71
160	3 69	1 440	4 64	10 3	6 25	193 8	12 1	5 54
165	3 58	1 485	4 79	10 0	6 06	187 9	11 7	5 37
170	3 47	1 530	4 93	9 73	5 88	182 4	11 4	5 21
175	3 37	1 575	5 08	9 45	5 71	177 1	11 1	5 06
180	3 28	1 620	5 23	9 19	5 55	172 2	10 8	4 92
185	3 19	1 665	5 37	8 94	5 41	167 6	10 5	4 79
190	3 11	1 710	5 52	8 70	5 26	163 2	10 2	4 66
195	3 03	1 755	5 66	8 48	5 13	159 0	9 94	4 54
200	2 95	1 800	5 81	8 27	5 00	155 0	9 69	4 43
205	2 88	1 845	5 95	8 07	4 88	151 2	9 45	4 32
210	2 81	1 890	6 10	7 87	4 76	147 6	9 23	4 22
215	2 75	1 935	6 24	7 69	4 65	144 2	9 01	4 12
220	2 68	1 980	6 39	7 52	4 54	140 9	8 81	4 03
225	2 62	2 025	6 33	7 35	4 44	137 8	8 61	3 94
230	2 57	2 070	6 68	7 19	4 35	134 8	8 42	3 85
235	2 51	2 115	6 82	7 04	4 26	131 9	8 25	3 77
240	2 46	2 160	6 97	6 89	4 17	129 2	8 07	3 69
245	2 41	2 205	7 11	6 75	4 08	126 5	7 91	3 62
250	2 36	2 250	7 26	6 61	4 00	124 0	7 75	3 54
255	2 32	2 295	7 40	6 49	3 92	121 6	7 60	3 47
260	2 27	2 340	7 55	6 36	3 85	119 2	7 45	3 41
265	2 23	2 385	7 69	6 25	3 77	117 0	7 31	3 34
270	2 19	2 430	7 84	6 12	3 70	114 8	7 18	3 28
275	2 15	2 475	7 98	6 01	3 64	112 7	7 05	3 22

Table 12 Tex to Other Count Systems — *Contd*

Tex (T) (1)	Cotton Count (N_eC) (2)	Denier (T_d) (3)	Grist (T_t) (4)	Linen (N_eL) (5)	Metric (N_m) (6)	Woollen (Dewsbury) (N_d) (7)	Woollen (Yorkshire) (N_y) (8)	Worsted (N_eW) (9)
280	2 11	2 520	8 13	5 91	3 57	110 7	6 92	3 16
285	2 07	2 565	8 27	5 80	3 00	108 8	6 80	3 11
290	2 04	2 610	8 42	5 70	3 45	106 9	6 68	3 06
295	2 00	2 655	8 56	5 61	3 39	105 0	6 57	3 00
300	1 97	2 700	8 71	5 51	3 33	103 3	6 46	2 95
305	1 94	2 745	8 85	5 42	3 28	101 6	6 35	2 90
310	1 90	2 790	9 00	5 33	3 23	100 0	6 25	2 86
315	1 87	2 835	9 14	5 25	3 17	98 4	6 15	2 81
320	1 84	2 880	9 29	5 17	3 12	96 9	6 06	2 77
325	1 82	2 925	9 43	5 09	3 08	95 4	5 96	2 73
330	1 79	2 970	9 58	5 01	3 03	93 9	5 87	2 68
335	1 76	3 015	9 72	4 94	2 99	92 5	5 79	2 64
340	1 74	3 060	9 87	4 86	2 94	92 2	5 69	2 60
345	1 71	3 105	10 0	4 79	2 90	89 9	5 62	2 57
350	1 69	3 150	10 2	4 72	2 86	88 6	5 54	2 53
355	1 66	3 195	10 3	4 66	2 82	87 3	5 46	2 50
360	1 64	3 240	10 5	4 59	2 78	86 1	5 38	2 46
365	1 62	3 285	10 6	4 53	2 74	84 9	5 31	2 43
370	1 60	3 330	10 7	4 47	2 70	83 8	5 24	2 39
375	1 57	3 375	10 9	4 41	2 67	82 7	5 17	2 36
380	1 55	3 420	11 0	4 35	2 63	81 6	5 09	2 33
385	1 53	3 465	11 2	4 30	2 60	80 5	5 03	2 30
390	1 51	3 510	11 3	4 24	2 56	79 5	4 97	2 27
395	1 49	3 555	11 4	4 19	2 53	78 5	4 91	2 24
400	1 48	3 600	11 6	4 13	2 50	77 5	4 84	2 22
405	1 46	3 645	11 8	4 08	2 47	76 5	4 79	2 19
410	1 44	3 690	11 9	4 03	2 44	75 6	4 73	2 16
415	1 42	3 735	12 0	3 99	2 41	74 7	4 67	2 13
420	1 41	3 780	12 2	3 94	2 38	73 8	4 61	2 11
425	1 39	3 825	12 3	3 89	2 35	72 9	4 56	2 08
430	1 37	3 870	12 5	3 85	2 32	72 1	4 51	2 06
435	1 36	3 915	12 6	3 80	2 30	71 3	4 46	2 04
440	1 34	3 960	12 8	3 76	2 27	70 4	4 40	2 01
445	1 33	4 005	12 9	3 72	2 25	69 7	4 36	1 99
450	1 31	4 050	13 1	3 67	2 22	68 9	4 31	1 97
455	1 30	4 095	13 2	3 64	2 20	68 1	4 26	1 95
460	1 28	4 140	13 4	3 59	2 17	67 4	4 21	1 93
465	1 27	4 185	13 5	3 56	2 15	66 7	4 17	1 90
470	1 26	4 230	13 6	3 52	2 13	66 0	4 12	1 88
475	1 24	4 275	13 8	3 48	2 11	65 3	4 08	1 86
480	1 23	4 320	13 9	3 44	2 08	64 6	4 04	1 84
485	1 22	4 365	14 1	3 41	2 06	63 9	4 00	1 83
490	1 20	4 410	14 2	3 37	2 04	63 3	3 95	1 81
495	1 19	4 455	14 4	3 34	2 02	62 6	3 92	1 79
500	1 18	4 500	14 5	3 31	2 00	62 0	3 88	1 77

Table 12 Tex to Other Count Systems — *Contd.*

Tex (T_t) (1)	Cotton Count (N_eC) (2)	Denier (T_d) (3)	Grist (T_j) (4)	Linen (N_eL) (5)	Metric (N_m) (6)	Woollen (Dewsbury) (N_d) (7)	Woollen (Yorkshire) (N_y) (8)	Worsted (N_eW) (9)
505	1.17	4 545	14.7	3.28	1.98	61.4	3.84	1.75
510	1.16	4 590	14.8	3.24	1.96	60.8	3.79	1.74
515	1.15	4 635	15.0	3.21	1.94	60.2	3.76	1.72
520	1.14	4 680	15.1	3.18	1.92	59.6	3.73	1.70
525	1.12	4 725	15.2	3.15	1.90	59.0	3.69	1.69
530	1.11	4 770	15.4	3.12	1.89	58.5	3.66	1.67
535	1.10	4 815	15.5	3.09	1.87	57.9	3.62	1.66
540	1.09	4 860	15.7	3.06	1.85	57.4	3.59	1.64
545	1.08	4 905	15.8	3.03	1.83	56.9	3.56	1.63
550	1.07	4 950	16.0	3.01	1.82	56.4	3.52	1.61
555	1.06	4 995	16.1	2.98	1.80	55.9	3.49	1.60
560	1.05	5 040	16.3	2.95	1.78	55.4	3.46	1.58
565	1.05	5 085	16.4	2.93	1.77	54.9	3.43	1.57
570	1.04	5 130	16.5	2.90	1.75	54.4	3.39	1.55
575	1.03	5 175	16.7	2.88	1.74	53.9	3.37	1.54
580	1.02	5 220	16.8	2.85	1.72	53.4	3.34	1.53
585	1.01	5 265	17.0	2.83	1.71	53.0	3.31	1.51
590	1.00	5 310	17.1	2.80	1.69	52.5	3.28	1.50
595	0.992	5 355	17.3	2.78	1.68	52.1	3.26	1.49
600	0.984	5 400	17.4	2.76	1.66	51.7	3.23	1.48
605	0.976	5 445	17.6	2.73	1.65	51.2	3.20	1.46
610	0.968	5 490	17.7	2.71	1.64	50.9	3.18	1.45
615	0.960	5 535	17.9	2.69	1.63	50.4	3.15	1.44
620	0.952	5 580	18.0	2.67	1.61	50.0	3.13	1.43
625	0.945	5 625	18.1	2.65	1.60	49.6	3.10	1.42
630	0.937	5 670	18.3	2.62	1.59	49.2	3.08	1.41
635	0.930	5 715	18.4	2.60	1.57	48.8	3.05	1.39
640	0.923	5 760	18.6	2.58	1.56	48.4	3.03	1.38
645	0.916	5 805	18.7	2.56	1.55	48.1	3.00	1.37
650	0.909	5 850	18.9	2.54	1.54	47.7	2.98	1.36
655	0.902	5 895	19.0	2.53	1.53	47.3	2.96	1.35
660	0.895	5 940	19.2	2.51	1.52	47.0	2.94	1.34
665	0.888	5 985	19.3	2.49	1.50	46.6	2.91	1.33
670	0.881	6 030	19.4	2.47	1.49	46.3	2.89	1.32
675	0.875	6 075	19.6	2.45	1.48	45.9	2.87	1.31
680	0.868	6 120	19.7	2.43	1.47	45.6	2.85	1.30
685	0.862	6 165	19.9	2.41	1.46	45.3	2.83	1.29
690	0.856	6 210	20.0	2.40	1.45	44.9	2.81	1.28
695	0.850	6 255	20.2	2.38	1.44	44.6	2.79	1.27
700	0.844	6 300	20.3	2.36	1.43	44.3	2.77	1.26
705	0.838	6 345	20.5	2.35	1.42	44.0	2.75	1.26
710	0.832	6 390	20.6	2.33	1.41	43.7	2.73	1.25
715	0.826	6 435	20.8	2.31	1.40	43.4	2.71	1.24
720	0.820	6 480	20.9	2.30	1.39	43.1	2.69	1.23
725	0.814	6 525	21.0	2.28	1.38	42.8	2.67	1.22

Table 12 Tex to Other Count Systems — *Contd*

Tex (T_t) (1)	Cotton Count (N_eC) (2)	Denier (T_d) (3)	Grist (T_j) (4)	Linen (N_eL) (5)	Metric (N_m) (6)	Woollen (Dewsbury) (N_d) (7)	Woollen (Yorkshire) (N_y) (8)	Worsted (N_eW) (9)
730	0 809	6 570	21 2	2 27	1 37	42 5	2 65	1 21
735	0 803	6 615	21 3	2 25	1 36	42 2	2 64	1 21
740	0 798	6 660	21 5	2 23	1 35	41 9	2 62	1 19
745	0 793	6 705	21 6	2 22	1 34	41 6	2 60	1 19
750	0 787	6 750	21 8	2 20	1 33	41 3	2 58	1 18
755	0 782	6 795	21 9	2 19	1 32	41 1	2 57	1 17
760	0 777	6 840	22 1	2 18	1 32	40 8	2 55	1 17
765	0 772	6 885	22 2	2 16	1 31	40 5	2 53	1 16
770	0 767	6 930	22 4	2 15	1 30	40 3	2 52	1 15
775	0 762	6 975	22 5	2 13	1 29	40 0	2 50	1 14
780	0 757	7 020	22 6	2 12	1 28	39 8	2 48	1 14
785	0 752	7 065	22 8	2 11	1 27	39 5	2 47	1 13
790	0 748	7 110	22 9	2 09	1 26	39 3	2 45	1 12
795	0 743	7 155	23 1	2 08	1 26	39 0	2 44	1 11
800	0 738	7 200	23 2	2 07	1 25	38 8	4 42	1 11
805	0 734	7 245	23 4	2 05	1 24	38 5	2 41	1 10
810	0 729	7 290	23 5	2 04	1 23	38 3	2 39	1 09
815	0 720	7 335	23 7	2 03	1 23	38 0	2 38	1 09
820	0 720	7 380	23 8	2 02	1 22	37 8	2 36	1 08
825	0 716	7 425	23 9	2 00	1 21	37 6	2 35	1 07
830	0 711	7 470	24 1	1 99	1 20	37 4	2 33	1 07
835	0 707	7 515	24 2	1 98	1 20	37 1	2 32	1 06
840	0 703	7 560	24 4	1 97	1 19	36 9	2 31	1 05
845	0 699	7 605	24 5	1 96	1 18	36 7	2 29	1 05
850	0 695	7 650	24 7	1 95	1 18	36 5	2 28	1 04
855	0 691	7 695	24 8	1 93	1 17	36 3	2 27	1 04
860	0 687	7 740	25 0	1 92	1 16	36 0	2 25	1 03
865	0 683	7 785	25 1	1 91	1 16	35 8	2 24	1 02
870	0 679	7 830	25 3	1 90	1 15	35 6	2 23	1 02
875	0 675	7 875	25 4	1 89	1 14	35 4	2 21	1 01
880	0 671	7 920	25 5	1 88	1 14	35 2	2 20	1 01
885	0 667	7 965	25 7	1 87	1 13	35 0	2 19	1 00
890	0 664	8 010	25 8	1 86	1 12	34 8	2 18	1 00
895	0 660	8 055	26 0	1 85	1 12	34 6	2 17	0 989
900	0 656	8 100	26 1	1 84	1 11	34 4	2 15	0 984
905	0 652	8 145	26 3	1 83	1 10	34 3	2 14	0 979
910	0 649	8 190	26 4	1 82	1 10	34 1	2 13	0 973
915	0 645	8 235	26 6	1 81	1 09	33 9	2 12	0 968
920	0 642	8 280	26 7	1 80	1 09	33 7	2 11	0 963
925	0 638	8 325	26 9	1 79	1 08	33 5	2 09	0 958
930	0 635	8 370	27 0	1 78	1 08	33 3	2 08	0 952
935	0 632	8 415	27 1	1 77	1 07	33 2	2 07	0 947
940	0 628	8 460	27 3	1 76	1 06	33 0	2 06	0 942
945	0 625	8 505	27 4	1 75	1 06	32 8	2 05	0 937
950	0 622	8 550	27 6	1 74	1 05	32 6	2 04	0 932

Table 12 Tex to Other Count Systems — *Contd.*

Tex (T_t) (1)	Cotton Count ($N_e C$) (2)	Denier (T_d) (3)	Grist (T_l) (4)	Linen ($N_e L$) (5)	Metric (N_m) (6)	Woollen (Dewsbury) (N_d) (7)	Woollen (Yorkshire) (N_y) (8)	Worsted ($N_e W$) (9)
955	0 618	8 595	27 7	1 73	1 05	32 5	2 03	0 928
960	0 615	8 640	27 9	1 72	1 04	32 3	2 02	0 923
965	0 612	8 685	28 0	1 71	1 04	32 1	2 01	0 918
970	0 609	8 730	28 2	1 70	1 03	32 0	2 00	0 913
975	0 606	8 775	28 3	1 70	1 03	31 8	1 99	0 909
980	0 603	8 820	28 4	1 69	1 02	31 6	1 98	0 904
985	0 599	8 865	28 6	1 68	1 02	31 5	1 97	0 899
990	0 597	8 910	28 7	1 67	1 01	31 3	1 96	0 895
995	0 594	8 955	28 9	1 66	1 01	31 2	1 95	0 890
1 000	0 591	9 000	29 0	1 65	1 00	31 0	1 94	0 886
1 010	0 585	9 090	29 3	1 64	0 990	30 7	1 92	0 877
1 020	0 579	9 180	29 6	1 62	0 980	30 4	1 90	0 868
1 030	0 573	9 270	29 9	1 61	0 971	30 1	1 88	0 860
1 040	0 568	9 360	30 2	1 60	0 962	29 8	1 86	0 852
1 050	0 562	9 450	30 5	1 58	0 952	29 5	1 85	0 844
1 060	0 557	9 540	30 8	1 56	0 943	29 2	1 83	0 836
1 070	0 552	9 630	31 1	1 55	0 935	29 0	1 81	0 828
1 080	0 547	9 720	31 4	1 53	0 926	28 7	1 79	0 820
1 090	0 542	9 810	31 6	1 52	0 917	28 4	1 78	0 813
1 100	0 537	9 900	31 9	1 50	0 909	28 2	1 76	0 805
1 110	0 532	9 990	32 2	1 49	0 901	27 9	1 75	0 798
1 120	0 527	10 080	32 5	1 48	0 893	27 7	1 73	0 791
1 130	0 522	10 170	32 8	1 46	0 885	27 4	1 72	0 784
1 140	0 518	10 260	33 1	1 45	0 877	27 2	1 70	0 777
1 150	0 514	10 350	33 4	1 44	0 870	27 0	1 69	0 770
1 160	0 509	10 440	33 7	1 43	0 862	26 7	1 67	0 764
1 170	0 505	10 530	34 0	1 41	0 855	26 5	1 66	0 758
1 180	0 500	10 620	34 3	1 40	0 847	26 3	1 64	0 751
1 190	0 496	10 710	34 5	1 39	0 840	26 0	1 63	0 744
1 200	0 492	10 800	34 8	1 38	0 833	25 8	1 62	0 738
1 210	0 488	10 890	35 1	1 37	0 826	25 6	1 60	0 732
1 220	0 484	10 980	35 4	1 36	0 820	25 4	1 59	0 727
1 230	0 480	11 070	35 7	1 34	0 813	25 2	1 58	0 720
1 240	0 476	11 160	36 0	1 33	0 806	25 0	1 56	0 714
1 250	0 472	11 250	36 3	1 32	0 800	24 8	1 55	0 709
1 260	0 469	11 340	36 6	1 31	0 794	24 6	1 54	0 703
1 270	0 465	11 430	36 9	1 30	0 787	24 4	1 53	0 697
1 280	0 461	11 520	37 2	1 29	0 781	24 2	1 51	0 692
1 290	0 458	11 610	37 4	1 28	0 775	24 0	1 50	0 687
1 300	0 454	11 700	37 7	1 27	0 769	23 8	1 49	0 681
1 310	0 451	11 790	38 0	1 26	0 763	23 7	1 48	0 676
1 320	0 447	11 880	38 3	1 25	0 758	23 5	1 47	0 671
1 330	0 444	11 970	38 6	1 24	0 752	23 3	1 46	0 666
1 340	0 441	12 060	38 9	1 23	0 746	23 1	1 45	0 661
1 350	0 437	12 150	39 2	1 22	0 741	23 0	1 44	0 656

Table 12 Tex to Other Count Systems — *Contd*

Tex (T_t) (1)	Cotton Count (N_eC) (2)	Denier (T_d) (3)	Grist (T_g) (4)	Linen (N_eL) (5)	Metric (N_m) (6)	Woollen (Dewsbury) (N_d) (7)	Woollen (Yorkshire) (N_y) (8)	Worsted (N_eW) (9)
1 360	0 434	12 240	39 5	1 22	0 735	22 8	1 43	0 651
1 370	0 431	12 330	39 8	1 21	0 730	22 6	1 41	0 647
1 380	0 428	12 420	40 1	1 20	0 725	22 5	1 40	0 642
1 390	0 425	12 510	40 4	1 19	0 719	22 3	1 39	0 637
1 400	0 422	12 600	40 6	1 18	0 714	22 1	1 38	0 633
1 410	0 419	12 690	40 9	1 17	0 709	22 0	1 37	0 628
1 420	0 416	12 780	41 2	1 16	0 704	21 8	1 36	0 624
1 430	0 413	12 870	41 5	1 16	0 699	21 7	1 36	0 619
1 440	0 410	12 960	41 5	1 15	0 694	21 5	1 35	0 615
1 450	0 407	13 050	42 1	1 14	0 690	21 4	1 34	0 611
1 460	0 404	13 140	42 4	1 13	0 685	21 2	1 33	0 607
1 470	0 402	13 230	42 7	1 13	0 680	21 1	1 32	0 603
1 480	0 399	13 320	43 0	1 12	0 676	20 9	1 31	0 598
1 490	0 396	13 410	43 3	1 11	0 671	20 8	1 30	0 594
1 500	0 394	13 500	43 5	1 10	0 667	20 7	1 29	0 591
1 510	0 391	13 590	43 8	1 10	0 662	20 5	1 28	0 587
1 520	0 388	13 680	44 1	1 09	0 658	20 4	1 28	0 583
1 530	0 386	13 770	44 4	1 08	0 654	20 3	1 26	0 579
1 540	0 383	13 860	44 7	1 07	0 649	20 1	1 26	0 575
1 550	0 381	13 950	45 0	1 07	0 645	20 0	1 25	0 571
1 560	0 378	14 040	45 3	1 06	0 641	19 9	1 24	0 568
1 570	0 376	14 130	45 6	1 05	0 637	19 7	1 23	0 564
1 580	0 374	14 220	45 9	1 05	0 633	19 6	1 23	0 561
1 590	0 371	14 310	46 2	1 04	0 629	19 5	1 22	0 557
1 600	0 369	14 400	46 4	1 03	0 625	19 4	1 21	0 554
1 610	0 367	14 490	46 7	1 03	0 621	19 3	1 20	0 550
1 620	0 364	14 580	47 0	1 02	0 617	19 1	1 20	0 547
1 630	0 362	14 670	47 3	1 01	0 613	19 0	1 19	0 543
1 640	0 360	14 760	47 6	1 01	0 610	18 9	1 18	0 540
1 650	0 358	14 850	47 9	1 00	0 606	18 8	1 17	0 537
1 660	0 356	14 940	48 2	0 996	0 602	18 7	1 17	0 534
1 670	0 354	15 030	48 5	0 990	0 599	18 6	1 16	0 530
1 680	0 351	15 120	48 8	0 985	0 595	18 5	1 15	0 527
1 690	0 349	15 210	49 1	0 979	0 592	18 3	1 15	0 524
1 700	0 347	15 300	49 4	0 973	0 588	18 2	1 14	0 521
1 710	0 345	15 390	49 6	0 967	0 585	18 1	1 13	0 518
1 720	0 343	15 480	49 9	0 962	0 581	18 0	1 13	0 515
1 730	0 341	15 570	50 2	0 956	0 578	17 9	1 12	0 512
1 740	0 339	15 660	50 5	0 951	0 575	17 8	1 11	0 509
1 750	0 337	15 750	50 8	0 945	0 571	17 7	1 11	0 506
1 760	0 336	15 840	51 1	0 940	0 568	17 6	1 10	0 503
1 770	0 334	15 930	51 4	0 934	0 565	17 5	1.09	0 500
1 780	0 332	16 020	51 7	0 929	0 562	17 4	1 09	0 498
1 790	0 330	16 110	52 0	0 924	0 559	17 3	1 08	0 495
1 800	0 328	16 200	52 3	0 919	0 556	17 2	1 08	0 492

Table 12 Tex to Other Count Systems — *Contd*

Tex (T_t) (1)	Cotton Count (N_eC) (2)	Denier (T_d) (3)	Grist (T_j) (4)	Linen (N_eL) (5)	Metric (N_m) (6)	Woollen (Dewsbury) (N_d) (7)	Woollen (Yorkshire) (N_y) (8)	Worsted (N_eW) (9)
1 810	0.326	16 290	52.5	0.914	0.552	17.1	1.07	0.489
1 820	0.324	16 380	52.8	0.909	0.549	17.0	1.06	0.487
1 830	0.323	16 470	53.1	0.904	0.546	16.9	1.06	0.484
1 840	0.321	16 560	53.4	0.899	0.543	16.8	1.05	0.481
1 850	0.319	16 650	53.7	0.894	0.541	16.8	1.05	0.479
1 860	0.317	16 740	54.0	0.889	0.538	16.7	1.04	0.476
1 870	0.316	16 830	54.3	0.884	0.535	16.6	1.04	0.474
1 880	0.314	16 920	54.6	0.880	0.532	16.5	1.03	0.471
1 890	0.312	17 010	45.9	0.875	0.529	16.4	1.03	0.469
1 900	0.311	17 100	55.2	0.870	0.526	16.3	1.02	0.466
1 910	0.309	17 190	55.4	0.866	0.524	16.2	1.01	0.464
1 920	0.308	17 280	55.7	0.861	0.521	16.1	1.01	0.461
1 930	0.306	17 370	56.0	0.857	0.518	16.1	1.00	0.459
1 940	0.304	17 460	56.3	0.853	0.515	16.0	0.999	0.457
1 950	0.303	17 550	56.6	0.848	0.513	15.9	0.994	0.454
1 960	0.301	17 640	56.9	0.844	0.510	15.8	0.989	0.452
1 970	0.300	17 730	57.2	0.840	0.508	15.7	0.984	0.450
1 980	0.298	17 820	57.5	0.835	0.505	15.7	0.979	0.447
1 990	0.297	17 910	57.8	0.831	0.503	15.6	0.974	0.445
2 000	0.295	18 000	58.1	0.827	0.500	15.5	0.969	0.443

DETERMINATION OF LINEAR DENSITY OF YARNS SPUN ON COTTON SYSTEM

(*Source* : IS 1315 : 1977)

1 SCOPE

It prescribes the procedure for determination of linear density of yarn spun on cotton system in cotton count and tex. It is applicable to single, plied and cabled yarns.

2 SAMPLING

The samples shall be drawn in accordance with the procedure laid down in IS 3920:1985 'Methods for sampling of cotton yarn for determination of physical characteristics (*see* Section A-1/1)'.

3 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

3.1 The sample shall be conditioned to moisture equilibrium in standard atmosphere of 65 + 2 percent relative humidity and 27 ± 2°C temperature (*see also* IS 6359:1971 'Method for conditioning of textiles').

3.2 The test shall be carried out in the standard atmosphere (*see* **3.1**).

4 APPARATUS

For the purpose of this test any of the following apparatus may be used depending upon the availability.

4.1 Any Special Balance

To indicate the linear density directly when a skein of known length of yarn is placed or hung on one side of the balance.

4.2 Pan Balance

Capable of measuring to an accuracy of 1 mg.

4.3 Wrap Reel

Having 1.372m (1.5 yd) or 1 m girth (*see* Annex A) and capable of reeling known lengths of yarn.

4.4 Yarn Tensioning Device

An adjustable tensioning device capable of giving a reeling tension that will result in skeins of the specified length when measured on a skein gauge. The adjustment in reeling tension may be made, for example, by making more than one wrap around thread guides or by passing the yarn around tensioning bars. The reeling tension shall be the same at all reeling positions and may be checked as follows:

The yarn is wound from the same package at different reeling positions. The length of the skeins when measured on a skein gauge shall not differ by more than 0.1 percent.

4.5 Skein Gauge

A gauge for checking the length of the skein under a load of 0.5 gf/tex (5 mN/tex) and expressing the length as a plus or minus deviation from the nominal length. The sensitivity of the skein gauge shall be sufficient to permit rejection of skeins falling outside ±0.25 percent tolerances. The skein-gauge length may be adjustable or non-adjustable. A non-adjustable skein gauge may be used when its nominal length differs by not more than 0.4 percent from the measured perimeter of the reel.

NOTE — For details of skein gauge (*see* Annex B).

5 PROCEDURE

5.1 Cotton Count System

5.1.1 *Special Yarn Count of Balance*

Prepare a skein of 109.73m (120yd) on the wrap reel (*see* Annex A) or take the specified length of yarn, and place or hang it on the balance and read off the linear density of yarn from the scale provided.

5.1.2 *Pan Balance*

Reel out skeins of 109.73 m (120 yd) on the wrap reel (*see* Annex A) and then determine their mass in grams individually on the balance correct to 1 mg. Calculate the linear density of yarn as given in **6.1**.

5.2 Tex System

5.2.1 *Special Yarn Count Balance*

Prepare a skein of 100 m on the wrap reel (*see* Annex A) or take the specified length of yarn, and place or hang it on the balance and read off the linear density of yarn from the scale provided.

5.2.2 *Pan Balance*

Reel out skeins of 100 m on the wrap reel (*see* Annex A) and determine their mass in grams, individually on the balance correct to 1 mg. Calculate the linear density of yarn as given in **6.2**.

5.3 Test At Least 30 Test Specimens

6 CALCULATIONS

6.1 Cotton Count System

Calculate linear density of cotton yarn in the cotton count system up to one decimal place by the following formula:

$$N_c = \frac{453\cdot6}{7\times m} = \frac{64\cdot8}{m}$$

where

N_c = cotton yarn count; and

m = mass of skein of 109.73 m (or 120 yd), in grams (*see* **5.1.2**).

6.2 Tex System

Calculate the linear density of yarn in tex system up to one decimal place by the following formula:

$$t = \frac{m}{100}\times 1\,000 = 10\,m$$

where

t = count of yarn in tex; and

m = mass of skein of 100 m, in grams (*see* **5.2.2**).

6.3 Calculate the average of all the values up to one decimal place and report it as the average linear density of yarn.

6.4 Calculate the coefficient of variation (CV) of all the linear density observations made.

6.5 For conversion of cotton count to tex system the following formula shall be used:

$$\text{tex} = \frac{590.5}{N_c}$$

6.5.1 For interconversion of values from one system to the other, reference to IS 3689:1966 'Conversion factors and conversion tables for yarn counts' (*see* Section B-2/1) may be made.

7 REPORT

The report shall include the following information:

a) Type of yarn,
b) Average linear density in cotton count system and tex system,
c) CV of linear density, and
d) Number of test specimens tested.

ANNEX A

(*Clauses* 4.3, 5.1.1, 5.1.2, 5.2.1 *and* 5.2.2)

PREPARATION OF SKEINS

A-1 APPARATUS

A-1.1 To reel off the skeins, a wrap reel having a girth of 1.372m (1.5 yd) or 1 m shall be used. The wrap reel shall be fitted with thread guides fixed on a horizontal bar which has a traverse of about 25 mm. The wrap reel shall also be provided with a counting device to indicate the length of yarn reeled out and bell to ring just before the last revolution or a reel that automatically stops after the required number of revolutions.

A-2 PROCEDURE

A-2.1 Mount a test package on the wrap reel. Pass the end through the thread guides taking care that the yarn shall be kept under sufficient tension to avoid kinks, curls and slack in the yarn on the one hand and stretch on the other (*see* Note) and lead it to the reel.

NOTE — If necessary, yarn may be wound full one turn around the thread guide.

A-2.2 Start the wrap reel. Running it at uniform speed, reel out a skein of required length. Cut and tie the trailing end of the skein to its leading end.

ANNEX B

(*Note under* 4.5)

SKEIN GAUGE

B-1 APPARATUS

B-1.1 The gauge consists essentially of two round metal pegs of about 1.25 cm diameter and 5 to 6 cm long, located in the same vertical plane. One of the pegs is fixed to the rigid frame of the instrument and the other is carried on the lever of a simple loading system, the fulcrum of which is low-friction bearing, which is also carried on the frame. At least one of the pegs should be free to rotate about its axis.

B-2 PROCEDURE

B-2.1 Place the skein without bunching, around the two pegs, and apply the appropriate load, for example, by hanging a weight on the end of the lever arm or by moving a sliding weight along the lever arm. The girth of the skein is indicated, on a scale attached to the frame of the instrument, by a pointer attached to the lever arm or by an index line on the end of the lever arm. If L is the actual girth of the wrap reel, d the diameter of the pegs, and D the distance between the axes of the pegs when the indicator registers on the scale the actual girth of the wrap reel, then

$$D = \frac{L}{2} - \frac{\pi d}{2}$$

DETERMINATION OF CRIMP AND COUNT OF YARN REMOVED FROM FABRICS

(*Source* : IS 3442:1980)

1 SCOPE

1.1 It prescribes the procedure for determination of crimp and count of yarn removed from any textile fabric in which yarns are intact and can be removed in measurable lengths. In case the fabric contains plied or cabled yarn, the method is applicable for determination of its resultant count.

1.2 The count of yarn determined by this method may not, however, be expected to agree with the count of grey yarn used for weaving the fabric because of the changes brought about in the yarn count by the processing treatments as well as the treatments prescribed in this standard for removal of the added matter.

1.3 This method is not suitable for those yarns removed from fabrics where considerable waviness remains after application of stipulated tension.

2 SAMPLING

Samples shall be so drawn as to be representative of the lot. Samples drawn in accordance with the procedure laid down in the material specification or as agreed to between the buyer and the seller shall be taken as representative of the lot. In case the test is to be performed on small samples of fabrics, care shall be taken to take specimens as representative as possible and it should be reported in the test report.

NOTE — In the case of cotton fabrics, samples from the lot shall be drawn in accordance with IS 3919:1966 'Methods for sampling cotton fabrics for determination of physical characteristics (*see* Section A-1/2)'.

3 APPARATUS

3.1 A device capable of measuring the straightened length of yarn provided with two clamps, the distance between which is adjustable and through one of which a known tension can be applied. Each clamp shall consist of two jaws, preferably metallic, having parallel gripping surfaces.

NOTE — Any available crimp tester may be used for the purpose.

3.2 Balance

Capable of weighing correct to a milligram.

4 PREPARATION OF TEST SPECIMENS

4.1 From the various portions of the fabric comprising the test sample (**2.1**), cut out 5 warpway test specimens P_1, P_2, P_3, P_4, and P_5, and 5 weftway test specimens T_1, T_2, T_3, T_4 and T_5, taking care that the same group of warp and weft yarns is not repeated (*see* Fig. 1). Each specimen shall be 250 mm long and of sufficient width to yield about 150 warp or weft yarns.

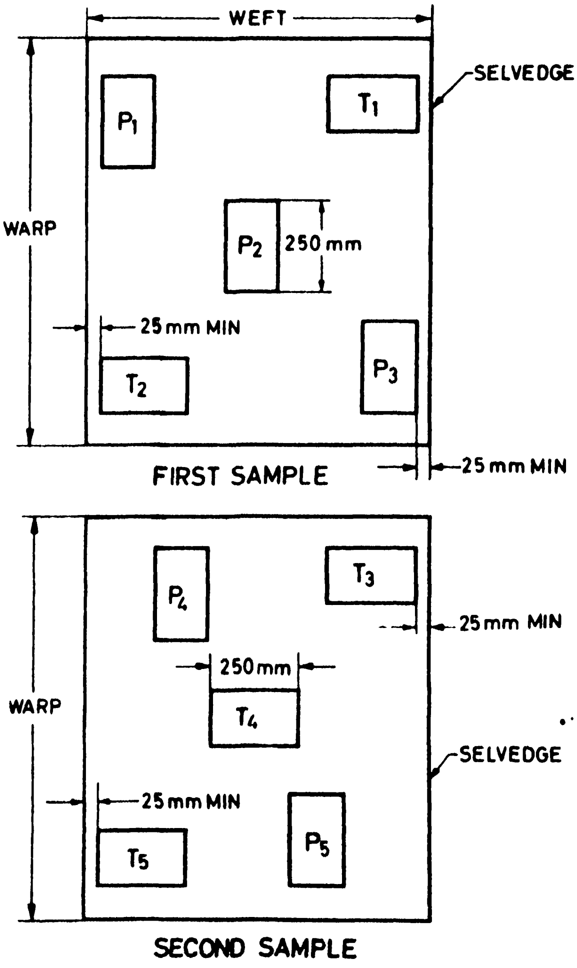


FIG. 1 LAYOUT OF TEST SPECIMENS

5 ATMOSPHERIC CONDITION FOR CONDITIONING AND TESTING

5.1. The test specimens shall be conditioned in standard atmospheric conditions of 65 ± 2°C percent relative humidity and 27 ± 2°C temperature to moisture equilibrium from dry side (*see* IS 6359:1971 'Method for conditioning of textiles' (Section B-1/1).

5.2 The tests shall be carried out in standard atmospheric conditions.

6 PROCEDURE

6.1 Warp Yarn

6.1.1 For determining the approximate universal count of the warp yarn in tex, which is necessary for calculating the tension to be applied during the test, take one of the warpway test specimens. Draw two parallel marks 200 mm apart at right angles to the direction of warp. Remove 10 warp yarns and cut them along the marks with a sharp razor blade and template. Determine the mass of all the yarns in milligrams and calculate the approximate universal count of the yarn in tex by the following formula:

$$t = \frac{m}{2}$$

where

t approximate universal count in tex of the warp yarn, and
m = mass in milligrams of 10 warp yarns.

6.1.2 Take the test specimen P_1 and draw two parallel marks 200 mm (l) apart at right angles to the direction of warp. Ravel a warp yarn out of the test specimen P_1 to a length of about 50 mm. Hold the yarn as close to the end as possible and fasten its loose end in the tension clamp so that one of the marks on the yarn coincides with the inner edge of the tension clamp. Pull the yarn out of the test specimen sideways, taking care not to stretch the yarn or release the other end of the yarn to avoid removal of any twist. Hold the yarn as close to the end as possible to avoid any untwisting. Draw the yarn through the other clamp and fix the yarn such that the second mark on the yarn coincides with the inner edge of the clamp. Measure the length of the yarn between the two marks in millimetres under a tension of 0.5 g/tex ± 10 percent (it should be noted that the tex of yarn determined as in **6.1.1** for this purpose is only approximate). In a similar manner, determine the length between the marks of 9 other warp yarns. From the data thus obtained, calculate the average straightened length between the marks (l_1) of 10 warp yarns.

6.1.3 Calculate the crimp percent in the yarn by the following formula:

$$= \frac{l_1 - l}{l} \times 100$$

where

l_1 = average length in millimetres of the yarns when straightened, and
l = length in millimetres of the yarns while in cloth.

NOTE — The crimp percent may be determined by using crimp tester, following the procedure as prescribed in the instrument manual

6.1.4 Cut the test specimen along the marks with a sharp razor blade and template. Remove sufficient number of warp yarns (*see* Note) out of the specimen so that the total length of the yarns removed is about 10 m, and place them in a suitable container.

NOTE — It may be necessary to trim off the protruding weft yarns frequently to avoid fraying of the warp yarns.

6.1.5 Calculate the total length (L) of the yarns collected in the container in millimetres taking the average length between the marks (l_1) determined as in **6.1.2**, as the length of each yarn.

6.1.6 Make the yarns into bundles or loops and remove the finishing material as given in Annex A. Determine the mass (M) of the yarns in milligram after conditioning (*see* **5.1**).

6.1.7 From the data thus onbtained, determine the universal count of the yarn in tex by the following formula:

$$\text{Universal count, in tex} = \frac{W}{L} \times 1\,000$$

where

M = total mass in milligrams of the yarns (**6.1.6**), and
L = total length in millimetres of the yarns (**6.1.5**).

6.1.8 Determine the crimp and count of the warp yarn in the remaining four test specimens, P_2, P_3, P_4, and P_5 in a similar manner. Find the average of the 5 values in each case, round off these values to one decimal place and report the values thus obtained as the crimp percent and count of the warp yarn.

NOTES

1 If it is desired to express the result in any of the traditional count systems, use one of the following formulae as applicable.

a) Count in the direct system $= \frac{M}{L} \times 1\,000 \times C_1$

where

M and L have the same meaning as in **6.1.7**, and
C_1 = constant corresponding to the count in the direct system in which the result is desired (*see* Table 1)

b) Count in the indirect system $= \frac{L}{M \times 1\,000} \times C_2$

where

M and L have the same meaning an in **6.1.7**, and
C_2 = a constant corresponding to the count in the indirect system in which the result is desired (*see* Table 2)

2 For factors and tables for conversion of yarn counts from one system to other, reference to IS 3689 1966 'Conversion factors and conversion tables for yarn counts' may be made (*see* Section B-2/1).

Table 1 Constants for Direct Count Systems

Yarn Count System	Unit of Mass Used	Unit of Length Used	Unit of Yarn Count	Constant C_1
(1)	(2)	(3)	(4)	(5)
Denier	1 gram	9 000 metres	g/9 000m	9
Jute	1pound	14 400 yards (spyndle unit)	lb/14 400 yd	0 029 03

6.2 Weft Yarn

Determine the crimp and count of the weft yarn by taking the test specimens T_1, T_2, T_3, T_4, and T_5 and following the procedure similar to the one prescribed in **6.1.1** to **6.1.8**.

6.3 In case the determination of the crimp of the yarn in the fabric is not required and only the count is to be determined, the straightened length and mass of the yarn after desizing may be used for calculating the count.

Table 2 Constant for Indirect Count Systems
(*Clause* 6.1.8)

Yarn Count System	Unit of Mass Used	Unit of Length Used	Unit of Yarn Count	Constant C_2
(1)	(2)	(3)	(4)	(5)
Cotton (English)	840 yards (hank)	1 pound	840 yd/lb	590.5
Linen (Wet spun)	300 yards (lea)	1 pound	300 yd/lb	1 654
Spun silk	840 yards	1 pound	840 yd/lb	590 5
Woollen (Dewsbury)	1 yard	1 ounce	yd/oz	31 000
Woollen (Yorksire)	256 yards (skein)	1 pound	256 yd/lb	1 938
Worsted	560 yards (hank)	1 pound	560 yd/lb	8 8 5 8

8 REPORT

8.1 The report shall include the following information:

a) Type of test sample
b) Average crimp percent
  1) Warp
  2) Weft
c) Average count
  1) Warp
  2) Weft

ANNEX A

(*Clause* 6.1.6)

TREATMENTS TO REMOVE SIZING AND OTHER FINISHING MATERIALS FROM THE SPECIMENS OR THE YARNS REMOVED FROM THEM

A-1 If the type of finishing material used is known, follow the method as recommended in IS 9068:1979. 'Recommended methods for the removal of non-fibrous matter prior to quantitative analysis of fibre mixtures'.

A-2 In case the type of finishing material is not known, proceed as follows:

Extract the specimens/yarns with benzene: methyl alcohol mixture in 3 : 2 ratio in a Soxhlet apparatus for 2 hours at a minimum rate of 6 cycles per hour (This removes oils, fats, waxes, certain thermoplastic resins, etc).

Extract the specimens/yarns with ethyl alcohol in a Soxhlet apparatus for 2 hours at a minimum rate of 6 cycles per hour (This removes soaps, cationic finishes, etc).

Treat the specimens yarns with 200 ml of water at 50°C for 30 minutes, stirring occasionally with glass rod or mechanically. Rinse thrice with fresh portions of warm water (at 50°C) and dry (This removes water soluble materials).

Immerse the specimens/yarns in 200 ml of 0.1 N hydrochloric acid at 80°C for 25 minutes, stirring gently every 3 minutes. Rinse throughly with water at 80°C containing a few drops of ammonia and then finally with plain water. Remove excess water from the sample by squeezing or suction centrifuge and allow to dry (This removes starches/aminoaldehyde compound resins).

DETERMINATION OF UNIVERSAL COUNT OF WOOLLEN AND WORSTED YARN

(*Source* : **IS 681:1964**)

1 SCOPE

It prescribes two methods for determination of universal count of woollen and worsted yarn. The methods are applicable to single or plied yarn.

NOTE — In the case of plied yarn, the methods are applicable for the determination of resultant count of the yarn.

2 PRINCIPLE

The first method is based on determining the weight of the specimen after conditioning it in the standard atmosphere. The second method is based on determining the weight of the specimen by drying it in a drying oven and calculating from this weight, its conditioned weight by adding the moisture regain value.

3 SAMPLING

3.1 Lot

All the bales (or cases) of yarn of the same count and quality delivered to one buyer against one despatch note shall constitute a lot.

3.2 The conformity of a lot to a specification shall be determined by tests carried on sample selected from the lot.

3.3 Unless otherwise agreed upon between the buyer and the seller, the number of bales (or cases) to be selected random from the lot shall be in accordance with col 1 and 2 of Table 1.

3.4 From each bale (or case) selected as in 3.3 two packages shall be selected at random.

3.5 From each of these packages two skeins shall be reeled off, each from a different portion, on a wrap reel with a girth of one metre (*see* Note).

When being reeled, the yarn shall be kept under sufficient tension to avoid kinks, curls and slacks in the yarn on the one hand, and stretch on the other, operating the reel at speed of about 100 rev/min. The length of each skein so reeled shall be in accordance with the applicable requirements of Table 2. All such skeins shall constitute the test specimens.

NOTE — During the period of progressive changeover from the fps system to the metric system of weights and measures, wrap reel of 1½ yd girth may be used.

Table 1 Number of Bales (or Cases) to be Selected

(*Clause* 3.3)

Number of Bales of Cases in the Lot (1)	Number of Bales of Cases to be Selected at Random (2)
3 or less	1
4 to 10	2
11 " 30	3
31 " 75	4
76 or more	5

Table 2 Length of Specimen

(*Clause* 3.5)

Universal Count (1)	No. of Turns of the Reel (2)	Length of Specimen (3)
		m
Below 20 tex	100	100
20 tex to 50 tex	50	50
Above 50 tex	25	25

NOTE — If, during the period of progressive changeover from the fps system of weights and measures to the metric system, it becomes necessary to use a wrap reel of 1½-yd girth, the length of specimen shall be as indicated below:

Universal Count	*No. of Turns of 1½-yd Reel*	*Length of Specimen*	
		yd	m
Below 20 tex	73	109.5	100.13
20 tex to 50 tex	36	54.0	49.38
Above 50 tex	18	27.0	24.69

4 ATMOSPHERIC CONDITIONS FOR TESTING

The test prescribed in **8.2.1** shall be carried out in a standard atmosphere at 65 ± 2 percent relative humidity and 27 ± 2° C temperature (*see also* IS 96:1966 'Atmospheric conditions for testing (*first revision*)' provided that throughout the test, the temperature does not vary by more than 1°C.

5 CONDITIONING OF TEST SPECIMENS

5.1 For the purpose of **8.2.1**, the test specimens shall be conditioned prior to evaluation in a standard atmosphere at 65 ± 2 percent relative humidity and 27 ± 2° C temperature, for 12 hours.

5.2 Prior to conditioning, the test specimens shall be pre-conditioned for one hour in a relative humidity of 10 percent and temperature of 50°C.

6 REAGENTS

6.1 Quality of Reagents

Unless specified otherwise, pure chemicals and distilled water (*see* IS 1070:1992 'Reagent grade water' (*third revision*) shall be used for the purpose of this test.

NOTE – 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the test results

6.2 For the purpose of this test, the following reagents shall be used.

6.2.1 *Benzene or Petroleum Hydrocarbon Solvent*

6.2.2 *Sodium Oleate Solution*

One percent (*w/v*).

7 APPARATUS

7.1 Drying Oven

Preferably of the ventilated type with positively induced draught, capable of maintaining an inside temperature of 105 to 110°C and provided with balance capable of weighing correct to 0.01g.

NOTE — If the oven is not provided with a balance, a suitable container to weight the samples to constant weight may be used.

7.2 Pan Balance

With weights in grams and capable of weighing accurate to 0.01 g.

8 PROCEDURE

8.1 Preliminary Extraction of the Test Specimen

Take a specimen (*see* 3.5) and extract it first with benzene or petroleum hydrocarbon solvent for three extractions and then treat it for 20 minutes in sodium oleate solution at 40 to 45°C with a material to liquor ratio of 1:30. Removing the specimen from the sodium oleate solution, rinse it three times in lukewarm water, each rinse lasting for about five minutes. Remove the surplus water by shaking the specimen two or three times and then pressing it gently between two folds of blotting paper. Dry the specimen in air.

NOTE — If the agreement between the buyer and the seller so provides, the test specimen may not be treated for preliminary extraction; the fact shall, however, be stated in the test report.

8.2 Determination of Count

Determine the count of yarn by any one of the following two methods, as agreed to between the buyer and the seller or as specified in the material specification. In case of dispute, however, the method prescribed in **8.2.2** shall be followed.

8.2.1 *First Method*

Condition the test specimen (*see* **5.1**). Weigh it correct to 0.01 g and note its weight. Calculate its universal count in the manner prescribed in **9**.

8.2.2 *Second Method*

Transfer the test specimen (*see* **8.1**) to the drying oven and dry it to constant weight (*see* Note). Determine the oven-dry weight of the test specimen.

NOTE — Constant weight may be assumed to have been attained by the specimen when two successive weighings at intervals of 20 minutes differ by less than 0.05 percent.

8.2.2.1 Calculate the conditioned weight of the test specimen by the formula given below:

$$\text{Conditioned weight of the test specimen} = \frac{A \times (100 + R)}{100}$$

where

A = oven-dry weight of the test specimen, and

R = moisture regain value of 18.25 percent for unchlorinated woollen and worsted yarns and 16 percent for chlorinated woollen and worsted yarns.

9 CALCULATION AND REPORT

9.1 Calculate the universal count of the test specimen using the formula given below:

$$\text{Universal count, in tex} = \frac{W}{L} \times 1\,000$$

where

W = weight in g of the test specimen determined either as in **8.2.1** or **8.2.2.1**, and

L = length in m of the test specimen.

9.2 Repeat the procedure prescribed in **8.1** and **8.2** with the remaining test specimens in the sample and determine their universal count in tex.

9.3 Calculate the mean of all the values and report it as the universal count in tex of the yarn in the lot. Report also the method followed for determining the universal count.

DETERMINATION OF LINEAR DENSITY OF MAN-MADE FIBRES CONTINUOUS FILAMENT FLAT YARNS

[*Source* : **IS 7703 (Part 1):1990**]

1 SCOPE

It prescribes the method for determination of linear density of man-made fibres continuous filament flat yarn.

2 PRINCIPLE

The linear density is determined from the mass of a specified length of yarn and expressed in denier or tex. The specimen is first conditioned free from tension and length is measured under standard pretension. The specimen is then oven-dried to constant mass and weighed. The commercial mositure regain is then added to the oven-dry mass and the resultant mass is used in calculating the linear density of the specimen.

3 SAMPLING

3.1 Sample to test conformity of a lot to a specification shall be selected so as to be representative of the lot.

3.2 Sample drawn in accordance with the procedure laid down in the relevant material specification or as agreed to between the buyer and the seller shall be held to be representative of the lot.

4 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

4.1 Unless otherwise agreed to between the buyer and the seller, the test sample shall be conditioned to a state of moisture equilibrium from the dry side in standard atmosphere at 65 ± 2 percent relative humidity and 27 ± 2°C temperature (*see* IS 6359:1971 'Method of conditioning of textiles' given in Section B-1/1)'.

NOTE — When a test sample under zero tension has been left in such a way as to expose, as far as possible, all portions of it to the standard atmosphere for 24 hours, the test sample shall be deemed to have reached a state of moisture equilibrium

4.2 The test shall be carried out in the standard atmosphere (*see* **4.1**).

5 APPARATUS

5.1 Pan Balance and Weights

Capable of weighing to test specimen to an accuracy of 0.1 mg.

5.2 Drying Oven

Provided with forced ventilation and positive valve control and capable of maintaining a temperature of 105 ± 3°C, preferably provided with a weighing balance. In case the weighing balance is not provided, a desiccator with a suitable desiccant and sealed containers of known mass shall be made available.

5.3 Wrap Reel

Capable of winding specific length under required tension.

6 PREPARATION OF TEST SPECIMENS

6.1 From each conditioned sample, draw suitable lengths of yarn preferable in multiples of 10 m for tex and 9 m for denier measurement by the wrap reel without alteration of twist under a constant yarn tension of 0.5 ± 0.1 cN/tex so that the mass of each specimen is at least 5 g. Discard a few metres of yarn while taking each specimen. Operate the reel by hand or motor (preferably the later) at a speed of 100 to 150 rev/min when reeling out yarn if it is in the skein form, use a speed of 200 to 300 rev/min for reeling out yarn from packages other than skeins. Tie the tail ends of the skein to its starting end. Measure the length of the yarn to an accuracy of 0.01 percent.

7 PROCEDURE

7.1 Take at least six test specimens, two from each package, one drawn from the inside and one drawn from the outside of the package, except when the yarn is on pirns. When the yarn is on pirns, take at least ten test specimens each reeled off from the middle portion of each pirn. Place each test specimen in the ventilated drying oven maintained at 105 ± 3°C and fed with air from standards atmosphere. Continue drying until constant mass is obtained.

NOTE - The mass shall be taken as constant when the difference between any two successive weighings made at intervals of 20 minutes does not exceed 0 1 percent.

7.2 Record the oven-dry mass of each test specimen correct to 1 mg.

8 CALCULATION

8.1 Calculate the linear density for each test specimen by one of the following formulae:

a) $\text{Tex} = (100 + R) \times \frac{10M}{L}$

b) $\text{Denier} = (100 + R) \times \frac{90M}{L}$

where

R = percentage commercial moisture regain of the fibre used in the yarn being tested (*see* Note),

M = Oven-dry mass of the test specimen in grams, and

L = length of specimen in metres.

NOTE — Unless otherwise agreed to between the buyer and the seller commercial moisture regain values for various man-made fibres as given below may be used:

Material	*Commerical Moisture Regain, Percent*
Polyester	0.4
Polyamide	4.5
Rayon	11.0
Cupro	11.0
Acetate	6.5
Acrylic	1.5
Vinyon (Polyvinyl chloride)	Zero
Olefins	Zero
Triacetate (primary)	3.5
Textile glass	Zero
Modacrylic	
Class 1	0.4
Class 2	2.0
Class 3	3.0

8.2 Find out the mean of the linear density values, obtained in **7.1**.

9 REPORT

The report shall include the following information:

a) The nature and composition of the material to be tested,
b) Linear density in tex or denier units,
c) Number of specimens tested,
d) Commerical moisture regain used,
e) Length yarn taken for each test specimen,
f) Month and year of manufacture of the material,
g) Product batch number, and
h) Indication of the source of manufacture.

DETERMINATION OF UNIVERSAL COUNT OF JUTE YARN

(*Source* : IS 570 : 1964)

1 SCOPE

It is prescribes two methods for determination of universal count of jute yarn. The methods are applicable to single, plied or cabled yarn.

NOTE — In the case of plied or cabled yarn, the methods are applicable for determination of its resultant count

2 PRINCIPLE

The first method is based on determining the universal count of yarn after conditioning the test specimens in the standard atmosphere. The second method is based on determining the weight of the specimen by drying it in a drying oven and calculating from this weight, its conditioned weight by adding the moisture regain value.

3 SAMPLING

3.1 Lot

Quantity of jute yarn of one definite count and quality delivered to one buyer against one despatch note.

3.2 The conformity of a lot to a specification shall be determined on the basis of test carried out on the sample selected from the lot.

3.3 Unless otherwise agreed upon between the buyer and the seller, the total number of bales (or trusses) to be taken at random from a lot shall be in accordance with the requirements of Table 1.

Table 1 Number of Bales or Trusses to be Selected from the Lot

No. of Bales (or Trusses) in a Lot (1)	No. of Bales (or Trusses) to be Taken (2)
2 to 25	1
26 ,, 50	2
51 ,, 75	3
76 ,, 100	4
Above 100	3 percent of the additional bales

3.4 One bundle of yarn shall be drawn from each of the bales (or trusses) drawn as in Table 1. However, if the number of bundles in a bale (or truss) is more than 25, two bundles shall be drawn from each of the bales (or trusses) drawn.

3.5 In case the yarn is on cones, the number of cones to be taken at random from the lot shall be in accordance with the requirements of Table 2.

Table 2 Number of Cones to be Selected from the Lot

No. of Cones in the Lot (1)	No. of Cones to be Selected (2)
Up to 100	2
101 " 150	3
151 " 500	5
501 " 1 000	8
1 001 " 3 000	13
3 001 and above	20

3.6 From each of the bundles drawn as in **3.4** two skein, each 100 m long, shall be reeled off from different parts of the bundle, on a wrap reel with a girth of two metres. When being reeled, the yarn shall be kept under sufficient tension to avoid kinks, curls and slacks in the yarn on the one hand, and stretch on the other, operating the reel at a speed of 100 to 200 rev/min. In case the yarn is on cones, one 100 m long skein shall be reeled off from each cone drawn as in **3.5**. The skeins so reeled shall constitute the test specimens.

3.6.1 In case the procedure prescribed in **3.6** provides less than 10 test specimens from the lot, further test specimens shall be taken from the selected bundles or cones (*see* **3.4** and **3.5**) to bring the number of test specimens up to 10.

4 ATMOSPHERIC CONDITIONS FOR TESTING

4.1 The test prescribed in **7.2** shall be carried out in a standard atmosphere at 65 ± 2 percent relative humidity and 27 ± 2°C temperature.

5 CONDITIONING OF SPECIMENS

5.1 When the test is to be carried out by the method prescribed in **7.2** prior to evaluation, the test specimens shall be left in the standard atmosphere at 65 ± 2 percent relative humidity and 27 ± 2°C temperature for 48 hours in such a way as to expose, as far as possible, all portions of the specimens to the atmosphere.

6 APPARATUS

For the purpose of this test, the following apparatus shall be used.

6.1 Drying Oven

Of a suitable capacity to hold about 500 g of yarn, preferably of the ventilated type with positively induced draught, capable of maintaining an inside temperature of 105 to 110° and provided with a balance which weighs correct to 0.1 g.

6.2 Pan Balance

With weights in grams and capable of weighing accurate to 0.1 g.

7 PROCEDURE

7.1 Determine the universal count of yarn by the method prescribed in **7.2** or **7.3** as agreed to between the buyer and the seller or as specified in the material specification. In case of dispute, however, the method specified in **7.3** shall be followed.

7.2 First Method

7.2.1 Take one of the conditioned skeins (*see* **5.1**) constituting the test specimens and weight it correct to the nearest 0.1 g. Calculate its universal count in the manner prescribed in **8**.

7.3 Second Method

7.3.1 Take a skein of yarn constituting the test specimens (*see* **3.5**) and dry it to constant weight at 105 to 110°C in the drying oven. Determine its constant weight. Stop the draught through the oven during weighing. Take the weight to be constant when the difference between the two consecutive weighings at an interval of 20 minutes is less than 0.1 percent of the first weight.

NOTE — In order to avoid risk in oil evaporation, the draught in the drying oven shall not be continued throughout the drying period but shall be in operation only intermittently

7.3.2 Calculate the conditioned weight of the skein by the formula given below:

$$\text{Conditioned weight of the skein} = \frac{A(100+R)}{100}$$

where

A = oven-dry weight, in g, of the specimen, and

R = moisture regain value of 17 percent.

8 CALCULATION AND REPORT

8.1 Calculate the universal count of the test specimen using the formula given below:

$$\text{Universal count, in tex} = \frac{W}{L} \times 1\,000$$

where

W = weight, in g, of the test specimen determined either as in **7.2.1** or **7.3.2**; and

L = length, in m, of the test specimen.

8.2 Repeat the procedure prescribed in **7.2** or **7.3** with the remaining test specimens in the sample and determine their universal count in tex.

8.3 Calculate the mean of all the values and report it as the universal count, in tex, of the yarn in the lot. Report also the method followed for determining the universal count.

9 CONVERSION OF GRIST INTO UNIVERSAL COUNT AND VICE-VERSA

9.1 For conversion of grist to universal count in tex, use the following formula:

$$T_t = T_j \times 34.45$$

where

T_t = universal count, in tex; and

T_j = grist, in lb

9.2 For conversion of universal count to grist, use the following formula:

$$T_j = T_t \times 0.029$$

where T_j and T_t are same as in **9.1**.

9.3 For convenience, Table 3 may, wherever possible, be used for converting grist values into universal count in tex.

Table 3 Grist to Universal Count, in Tex
(*Clause* 9.3)

Grist	0 tex	10 tex	20 tex	30 tex
0	-	345	690	1035
0.5	–	360	705	–
1.0		380	725	–
1.5	–	395	740	–
2.0		415	760	–
2.5	85	430	775	–
3.0	105	450	790	–
3.5	120	465	810	–
4.0	140	480	825	–
4.5	155	500	845	–
5.0	170	515	860	–
5.5	190	535	880	–
6.0	205	550	895	–
6.5	225	570	910	–
7.0	240	585	930	–
7.5	260	605	945	–
8.0	275	620	965	–
8.5	295	635	980	–
9.0	310	655	1 000	–
9.5	325	670	1 015	–

NOTE - Tex values rounded off to nearest 5 units.

DETERMINATION OF TWIST IN YARN

(*Source* : **IS 832 : 1985**)

Two methods are prescribed for determination of twist. Both the methods can be used for determination of twist in single spun, plied or cabled yarns. However, direct counting method (Method 1) is more suitable for plied and cabled yarns and untwist-retwist method. (Method II) does not give satisfactory result with open-end spun yarn, it is suitable only when approximation of true twist is required. For more accurate results Method I (direct counting method) may be adopted.'

1 SCOPE

1.1 It prescribes two methods for determination of direction of twist and amount of twist in terms of turns per metre of single spun plied and cabled yarn. In case of plied and cabled yarns, direct count method also provides for determination of twist take-up and twist release.

1.2 Methods prescribed are applicable to all textile yarns irrespective of their composition (that is, irrespective of whether a yarn is made of cotton, wool, silk, jute or man-made fibres or a blend of two or more such fibres).

1.3 Methods prescribed may be used to determine the twist of single, plied or cabled yarns removed from fabrics also.

NOTES

1 For plied yarns direct count method should be preferred as the values obtained by the untwist-retwist method are likely to be influenced by the direction of twist of yarns

2 However, in case of wool, it is not the practice to determine the twist of yarn removed from fabrics

3 The turns per metre of yarn removed from fabric may not have a fair relationship with the original twist inserted in the yarn during spinning, particularly in the case of crepe fabrics wherein the crepe effect is produced by the use of highly twisted yarns

4 The determination of turns per metre of yarn removed from fabric becomes impracticable when the fabric contains some types of finishing materials

2 SAMPLING

2.1 Yarn in Packages

2.1.1 *Lot*

All the bales (or cases) of yarn of the same type, count and quality delivered to one buyer against one despatch note shall constitute a lot.

2.1.2 The conformity of a lot to a specification shall be determined on the basis of tests conducted on the sample selected from the lot.

2.1.3 Unless otherwise agreed upon between the buyer and the seller, the number of bales (or cases) to be selected at random from the lot shall be in accordance with Table 1.

Table 1 Number of Bales (or Cases) to be Selected

(*Clause* 2.1.3)

Number of Bales (or Cases) the Lot (1)	Number of Bales (or Cases) to be Selected at Random (2)
3 or less	1
4 to 10	2
11 to 30	3
31 to 75	4
76 or more	5

2.1.4 From each of the bales (or cases) selected as in **2.1.3**, 10 packages shall be selected at random.

2.1.4.1 From each of these packages, an equal number of specimens of adequate length shall be selected from different parts of the package. The exact length and the total number of test specimens so drawn (from the packages) shall be in accordance with col 2 and 3 respectively of Table 2. Before cutting each test specimen from the package, a length of about 10 metres of yarn shall be discarded. While drawing the specimens from the packages, care shall be taken to avoid any change in the twist of yarn.

NOTE — As far as possible, the test specimens shall be drawn just before testing that is, each test specimen shall be tested soon after it is drawn from the package

2.2 Yarn from Cloth

2.2.1 *Lot*

All the bales (or cases) of cloth of the same construction and quality delivered to one buyer against one despatch note shall constitute a lot.

Table 2 Length and Number of Test Specimens

(*Clauses* 2.1.4.1, 2.2.4.1, 4.1, 4.2, 5.2.2.1, 5.2.3.3 *and* 6.2.3.2)

Type of Yarn	Direct Count Method		Untwist-Retwist Method	
	Length of Specimen	Number of Specimen	Length of Specimen	Number of Specimen
(1)	(2)	(3)	(4)	(5)
Single spun yarn				
Cotton type yarn	25 mm or below	100	250 mm or 500 mm	20
Worsted type yarn	50 mm or below	100	250 mm or 500 mm	20
Woollen type yarn	50 mm or below	100	250 mm or 500 mm	20
Jute type yarns:				
i) Single yarns	125 mm or below	20	250 mm or 500 mm	20
ii) Double yarns	250 mm or below	20	250 mm or 500 mm	20
Filament yarn	500 mm or below	10	250 mm or 500 mm	20
Plied or cabled yarns	500 mm or below	10	250 mm or 500 mm	20

2.2.2 The conformity of a lot to a specification shall be determined on the basis of tests conducted on the sample selected from the lot.

2.2.3 Unless otherwise agreed upon between the buyer and the seller, the number of bales (or cases) to be selected at random from the lot shall be in accordance with Table 1.

2.2.4 From each of the bales (or cases) selected as in **2.2.3**, 10 pieces shall be selected at random. From these pieces, number of warp or weft yarns as required, on which the test is to be conducted, shall be drawn as follows.

2.2.4.1 From each of the pieces selected as in **2.2.4**, an equal number of yarns (specimens) of adequate length shall be drawn from different parts of the piece. The length and the total number of specimens so drawn (in all cases) shall be in accordance with col 2 and 3 respectively of Table 2. While drawing three specimens from the pieces, care shall be taken to avoid any change in the twist of yarns.

NOTE — As far as possible, the test specimens shall be drawn just before testing, that is, each test specimen shall be tested soon after it is drawn from the piece of the cloth

3 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

3.1 Prior to test, the samples shall be conditioned to moisture equilibrium in the standard atmosphere of 65 ± 2 percent relative humidity and 27 ± 2°C temperature from dry side, as laid down is IS 6359 : 1971 'Method for conditioning of textiles' (*see* section B-1/1). The test shall be carried out in the standard atmosphere.

4 TEST SPECIMEN

4.1 Length of Test Specimen

The length of the test specimen between the inside edge of the clamps shall comply with the requirements of Table 2.

NOTE — In the case of direct count method (Method I) being used to determine twist in single spun yarn, the length of the specimen to be tested shall be less than the staple length of the fibre used to spin the yarn

4.2 Unless otherwise specified, the number of test specimens shall be in accordance with Table 2.

NOTE — The exact number of tests to be made for each type of yarn depends upon the estimated or assumed coefficients of variation of individual values and the permissible error in the estimate of the test results at a desired probability level. The value given in Table 2 for number of test specimens have been calculated assuming the following coefficients of variation for the respective individual values, with a permissible error of 5 percent at probability level of 95 percent

Type of Yarn	*Assumed Coefficient of Variation, Percent*	
	Direct Count Method	Untwist-Retwist Method
(1)	(2)	(3)
Yarn spun on cotton system	25	10.5
Yarn spun on worsted system	25	10.5
Yarn spun on woollen system	25	10.5
Jute yarn	25	10.5
Filament yarn	8	10.5
Plied or cabled yarn	8	10.5

If however, all the particulars for calculation of exact number of tests specimens are available, the test may be conducted accordingly

5 METHOD I DIRECT COUNT METHOD

5.1 Apparatus

The direct counting type twist tester shall conform to the following requirements:

a) The twist tester shall be provided with:

1) two clamps (or jaws) one rotatable and other non-rotatable to grip the test specimens;

2) a scale graduated in centimetres and millimetres to measure the distance between clamps;

3) a revolution counter positively connected to the rotatable clamp and capable of recording the number of revolutions of the clamps to an accuracy of:

   i) one turn, for testing specimen of length more than 50 mm;
   ii) one tenth of a turn, for testing specimen of length equal to or less than 50 mm and for testing yarn with low twist;

4) a suitable scale, graduated in millimetres to measure the elongation of contraction of the test specimen; and

5) a suitable magnifying glass to examine visually the test specimen during the test.

b) The distance between the clamps shall be capable of being set to any distance up to 500 mm as required.

c) The rotatable clamp shall be capable of being revolved in either direction on its axis common to the longitudinal axis of the test specimen.

d) The revolution counter shall be capable of being set to zero mark after each test.

e) The non-rotatable clamp shall be mounted on its support in such a manner that the required tension could be applied to the test specimen.

5.2 Procedure

5.2.1 *Direction of Twist*

Hold one end of the yarn in such a position that a short length (at least 100 mm) is suspended in a vertical position. Examine the vertical section of the yarn and determine if the shape of yarn elements conform to the shape of central portion of the letters '*S*' or '*Z*'. Note the direction of twist as '*S*' or '*Z*' as observed.

5.2.2 *Twist in Single Yarn*

5.2.2.1 Set the clamps so that the distance between the clamps is equivalent to the applicable value of the length of test specimen specified in Table 2 and ensure that the distance so set is within an accuracy of one percent of 0.5 mm whichever is greater. Set the revolution counter to zero position. Set the tensioning device so as to apply a tension of about tex/2 g ± 10 percent (*see* Note) on the test specimen.

NOTE — It is assumed that the universal count, in tex, of yarn under test would be known and if not known would be determined by weighing a known length of yarn taken from the conditioned sample. In case of jute yarns a pretension of tex/4g ± 10 percent may be used

5.2.2.2 Secure the free end of the test specimen in the non-rotatable clamp. Pass the other end of the specimen through the open rotatable clamp and pull it through the clamp till the specified pre-tension becomes effective, and then secure the specimen.

5.2.2.3 Determine the direction of twist, *S* or *Z* by visually testing the specimens.

5.2.2.4 Revolve the rotatable clamp in the proper direction so as to untwist the specimen. Continue the rotation in the same direction until it is possible to pass a needle from one clamp to the other between the untwisted fibre of the specimen; use the magnifying glass, if necessary, to make sure that all the twist has been removed. Note down the number of turns.

5.2.2.5 From the value obtained **5.2.2.4** and the length of the test specimen before untwisting, calculate the turns per metre in the test specimen.

5.2.2.6 By following the procedure **5.2.2.1** to **5.2.2.5** determine the turns per metre in the remaining test specimens. Calculate the mean of all the values so obtained and the coefficient of variation.

5.2.3 *Twist in Plied Yarn*

5.2.3.1 Determing the direction of twist and the number of turns in the test specimens by following the procedure prescribed in **5.2.2.1** to **5.2.2.4** but noting, for the purpose of **5.2.2.4** the end-point of the test when it is possible to pass a needle between component yarns of the specimen. Record also the extension in length obtained on untwisting the test specimen.

5.2.3.2 From the value of number of turns obtained in **5.2.3.1** and the length of the specimen before untwisting, calculate the turns per metre in the test specimen.

5.2.3.3 Cut off all but one component stand of single yarn close to the inside edges of the clamps. Test the component stand (still in the clamps) of single yarn for the direction of twist and the number of turns by following the procedure given under **5.2** and **5.2.2** but adjusting the length of the test specimen to comply with the requirements of Table 2.

NOTE It is assumed that all the component single yarns have the same amount of twist If this fact is not known, it should be verified If it is found that they differ in respect of the amount of twist, each component yarn shall be tested and the results reported

5.2.3.4 Test similarly the remaining test specimens for turns per metre of the plied yarn and the component single yarns, and twist take-up and twist-release of plied yarn. Calculate the mean of all the values so obtained and the coefficient of variation of the values.

5.2.4 *Twist in Cabled Yarn*

5.2.4.1 Determine the direction of twist, and the number of turns in the test specimens by following the procedure prescribed in **5.2.2.1** to **5.2.2.4** but noting, for the purpose of **5.2.2.4** the end point of the test when it is possible to pass a needle between the strands of the component plied yarn of the specimen Record also the extension in length obtained on untwisting the test specimen.

5.2.4.2 From the value of number of turns obtained in **5.2.4.1** and the length of the specimen before untwisting, calculate the turns per metre in the test specimen

5.2.4.3 Cut off all but one component strand of the plied yarn, close to the inside edges of the clamps. Test the component strand of plied yarn for the direction of twist and the number of turns per metre, in the plied and component single yarns (still in the clamps) by following the procedure given in **5.2.3**.

NOTE It is assumed that all the component plied yarns have the same amount of twist If this fact is not known, it should be verified If it is found that they differ in respect of the amount of twist, each component yarn shall be tested and the results reported

5.2.4.4 Test similarly the remaining test specimens for turns per metre of the cabled yarn, of the component plied yarns, and of the component single yarns; the twist take-up and twist-release of cabled yarn and of plied yarn. Calculate the mean of all the valued so obtained and the coefficient of variation of turns per metre values.

6 METHOD II UNTWIST-RETWIST METHOD

6.1 Apparatus

The untwist-retwist type of twist tester shall conform to the following requirements:

a) The twist tester shall be provided with:
    1) a pair of jaws - the rotatable and other non-rotatable 9 (called movable) - to hold the specimen of yarn by each of its extremities;
    2) a revolution counter positively connected to rotatable jaw and capable of recording the number of revolution of the jaw;
    3) means of a sliding support so that the distance between the jaws may be adjustable in order to permit measurements of the length of yarn;
    4) a scale graduated in centimetre and millimetre to measure the distance between the jaws;
    5) means shall be provided either by dead weight or by displacement of vertical pendulum for applying tension to the specimen and maintaining that tension until permitted elongation is obtained;
    6) means shall also be provided for rapidly determining the specimen length to an acuracy of ± 0.5 mm; and
    7) means shall also be provided to prevent specimen under test extending more than 2 percent, for example by means of stop.

b) Rotatable jaw may be motor driven or hand driven at speed in excess of 820 turns per minute;

c) Movable jaw, situated in the extension of the arm of rotatable jaw is mounted so that it is capable of being displaced and stopped in the direction of this axis;

d) Movable jaw shall not be able to be turned about its own axis;

e) The sliding support shall not permit play affecting the length of test specimen;

f) The distance between the jaws shall be capable of being set to any distance as required; and

g) Revolution counter shall be capable of being set to zero mark after each test.

6.2 Procedure

6.2.1 Direction of Twist

Determine the direction of twist in the yarn by the procedure mentioned at **5.2.1**.

6.2.2 *Twist in Single Yarn*

6.2.2.1 Position the movable jaw so that the distance between the jaws 250 or 500 mm. Adjust the tensioning device to apply a tension of tex/2g ± 10 percent. Set the yarn specimen elongation stop so that tension ceases to be applied after the yarns are extended by 1 percent set the revolution counter to zero.

6.2.2.2 Taking care not to disturb the twist, secure the free end of test specimen in the movable jaw (non-rotatable). Pass the other end of the specimen through the open rotatable jaw and pull it through the jaw till the specified pretension becomes effective and then secure the specimen.

6.2.2.3 Untwist the yarn operating the rotating jaw at a speed of at least 800 turns per minute. Then retwist the yarn in the opposite direction until the specimen elongation indicator returns to zero. Records the number of turns in the counter. Reset the counter to zero before testing a new specimen.

6.2.2.4 From the value obtained **6.2.2.3** and length of the test specimen before untwisting, calculate the number of turns per metre by the following formula:

$$tpm = \frac{500n}{l}$$

where

tpm = turns per metre,
n = number of revolutions measured from revolution counter to untwist and retwist the yarn, and
l = length of test specimen in mm.

6.2.2.5 By following the procedure given in **6.2.2.1** to **6.2.2.4** determine the turn per metre of the remaining test specimens. Calculate the mean of all values and coefficient of variation of the values.

6.2.3 *Twist in Plied Yarn*

6.2.3.1 Determine the number of turns per metre by following the procedure prescribed in **6.2.2.1** to **6.2.2.5** and direction of twist as prescribed in **6.2.1**.

6.2.3.2 Cut off all but one component strand of single yarn close to the inside edges of the jaws. Test the component strand (still in jaws) of single yarn for the direction of twist and number of turns by following the procedure given in **6.2** but adjusting the length of the specimen to comply with the requirements of Table 2.

NOTE — It is assumed that all the component single yarns have the same amount of twist. If this fact is not known, it should be verified If it is found that they differ in respect of the amount of twist, each component yarn shall be tested and the results reported

6.2.3.3 Test similarly the remaining test specimen for turns per metre of the plied yarn and of the component single yarn. Calculate the mean of the values so obtained and the coefficient of variations of the values.

6.2.4 *Twist in Cabled yarn*

6.2.4.1 Determine the direction of twist of test specimens as prescribed in **6.2.1** and number of turns per metre by following procedure prescribed in **6.2.2.1** to **6.2.2.5**.

6.2.4.2 Cut off all but one component strand of the plied yarn, close to the inside edges of the jaws. Test the component strand of plied yarn for the direction of twist and number of turns per metre in plied and component single yarns (still in the jaws) by following procedure given under **6.2.3**.

NOTE It is assumed that all the component plied yarns have the same amount of twist If this fact is not known, it shall be verified If it is found that they differ in respect of the amount of twist, each component yarn shall be tested and the results reported

6.2.4.3 Test similarly the remaining test specimens for turns per metre of the cabled yarn, of the component plied yarns of the component single yarns. Calculate the mean of all the values so obtained and coefficient of variation of turns per metre values.

7 REPORT

The test report shall include the following:

a) Type of yarn;
b) Method used, Method I or Method II;
c) Direction of twist 'S' or 'Z' of plied yarn and of the component single yarns;
d) Length in millimetres of the specimen;
e) Number of specimens tested;
f) Pre-tension used;
g) Mean value of turns per metre of plied yarn and of component single yarn;
h) Coefficient of variation of turns per metre value of plied yarn, if desired;
j) Mean value of twist take-up and twist-release of plied yarn;
k) Mean value of the turns per metre of the cabled yarn and the coefficient of variation of the turns per metre values, if desired; and
m) Mean value of the twist take-up and twist-release of the cabled yarn.

DETERMINATION OF YARN STRENGTH PARAMETERS OF YARNS SPUN ON COTTON SYSTEM

(*Source* : IS 1671 : 1977)

1 SCOPE

1.1 It prescribes methods for determination of yarn strength parameters of yarns spun on cotton system using cotton count and tex system.

1.1.1 In cotton count system, determination of lea breaking load and count strength product (CSP) have been prescribed and in the metric system, determination of skein breaking load, yarn strength index (YSI) and skein breaking tenacity (SBT) have been prescribed.

2 SAMPLING

The samples shall be drawn in accordance with the procedure laid down in IS 3920:1985 'Methods for sampling of cotton yarn for determination of physical characteristics' (*see* Section A-1/1).

3 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

3.1 The samples shall be conditioned to moisture equilibrium in standard atmosphere of 65 ± 2 percent relative humidity and 27 ± 2°C temperature [*see also* IS 6359 : 1971 'Method for conditioning of textiles' given in Section B-1/1].

3.2 The test shall be carried out in the standard atmosphere (*see* 3.1).

4 APPARATUS

4.1 Testing Machine

A skein breaking load testing machine working on constant rate-of-traverse (CRT) principle. Its rate of traverse shall be 300 ± 15 mm/min and the load range of the machine shall be such that the observed values would lie between 10 and 90 percent of the full scale load. The permissible error in the machine at any point in this range shall not exceed ± 1 percent.

4.1.1 The machine shall be provided with the following arrangements:

a) Two pulleys or hooks for holding the skein with sufficient space to allow the even distribution of threads without much overlapping.

b) Means for adjusting distance between the pulleys or hooks.

c) A scale or dial or autograph recording chart graduated so as to give load in kilograms.

4.2 Wrap-Reel

Having a girth of 1.372m (1.5yd) or 1 m and capable of reeling known length of yarn (*see* Annex A).

4.3 Yarn Tensioning Device

An adjustable tensioning device capable of giving a reeling tension that will result in skeins of the specified length when measured on a skein gauge. The adjustment in reeling tension may be made, for example, by making more than one wrap around thread guides or by passing the yarn around tensioning bars. The reeling tension shall be the same at all reeling positions and may be checked as follows:

The yarn is wound from the same package at different reeling positions. The length of the skeins when measured on a skein gauge shall not differ by more than 0.1 percent.

4.4 Skein Gauge

A gauge for checking the length of the skein under a load of 0.5 gf/tex (5 mN/tex) and expressing the length as a plus or minus deviation from the nominal length. The sensitivity of the skein gauge shall be sufficient to permit rejection of skeins falling outside ± 0.25 percent tolerances. The skein-gauge length may be adjustable or non-adjustable. A non-adjustable skein gauge can be used when its nominal length differs by no more than 0.4 percent from the measured perimeter of the reel.

NOTE — For details of skein gauge (*see* Annex B).

5 PREPARATION OF TEST SPECIMENS

5.1 Prepare skeins of 109.73 m (120 yd), 100 m or 50 m as required, following the procedure as described in Annex A.

5.2 Prepare at least 30 test specimens and condition them as in **3**.

6 PROCEDURE

6.1 Bring pulleys or the hooks of the testing machine to the zero position. Take the conditioned skein of yarn and fix it on the pulleys or hooks. Carefully separate the yarn on the pulleys or hooks to avoid the individual strands overlapping each other.

6.2 Start the machine and carry the test to rupture. Record the skein breaking load in kilograms as indicated on the scale, dial or recording chart.

6.3 Determine the mass in grams of the broken skein and calculate the linear density of yarn in cotton count or tex system (as the case may be) (*see* IS 1315 : 1977 'Method for determination of linear density of yarns spun on cotton system') (*see* Section B-2/2).

6.4 Determine the skein breaking load and linear density of yarn of the remaining specimens following the procedure as laid down in **6.1** to **6.3**.

7 CALCULATIONS

7.1 Calculate the average breaking load and average linear density of all the observations taken (*see* **6.2**, **6.3** and **6.4**).

7.1.1 Calculate the coefficient of variation (CV) of all the breaking load values taken.

7.2 Cotton Count System

7.2.1 *Count Strength Product* (*CSP*)

Calculate the count strength product or count strength product corrected to nominal count, correct to a whole number, from the following formulae:

a) CSP $= L_1 \times N_e$

b) CSP (Corrected) $= L_{1c} \times N_e'$

where

L_1 = average breaking load, in pounds (kg × 2.2), of the lea (*see* **7.1**);
N_e = average cotton count (*see* **7.1**);
L_{1c} = average breaking load, in pounds (kg × 2.2), corrected to nominal count (*see* Annex C); and
N_e' = nominal cotton count.

7.3 Tex System

7.3.1 *Skein Breaking Tenacity* (*SBT*)

Calculate the tenacity or tenacity of yarn corrected to nominal linear density, correct to one decimal place, by the following formulae:

a) SBT in grams per tex $\dfrac{L_2 \times 1\,000}{t \times 2 \times 50} = \dfrac{L_2 \times 10}{t}$

b) SBT (Corrected) $= \dfrac{L_{2c} \times 10}{t'}$

where

L_2 = average breaking load of 50 m skein, in kg (*see* **7.1**);
t = average linear density of yarn, in tex (*see* **7.1**);
L_{2c} = average breaking load of 50 m skein, in kg, corrected to nominal linear density (*see* Annex C); and
t' = nominal linear density, in tex.

7.3.2 *Yarn Strength Index (YSI)*

Calculate the yarn strength index corrected to nominal linear density, correct to a whole number by the following formulae:

a) YSI $= \dfrac{L_3 \times 1\,000}{t}$

b) YSI (Corrected) $= \dfrac{L_{3c} \times 1\,000}{t'}$

where

L_3 = average breaking load of 100 m skein, in kg (*see* **7.1**),
t = average linear density of yarn, in tex (*see* **7.1**),
L_{3c} = average breaking load of 100 m skein, in kg, corrected to nominal linear density (*see* Annex C), and
t' = nominal linear density, in tex.

NOTE — It has been found that for a given yarn, the Yarn Strength Index and Count Strength Product are numerically the same for **all** practical purposes. However, to calculate the yarn strength index of a skein from the count strength product of a lea (or *vice-versa*), the specified, observed or calculated breaking load value of the skein shall be converted into breaking load value of a lea (or *vice-versa*) using the formula given in Annex D

8 REPORT

The report shall include the following information:

a) Type of material;
b) Number of specimens tested;

b) Number of specimens tested;

c) Breaking load of skein [109.73m (120 yds) 50 m or 100 m];

OR

Breaking load of skein corrected to nominal count/linear density;

d) Coefficient of variation (CV) of breaking load values;

e) Count strength product (CSP) / Count strength product (CSP) corrected to nominal count (correct to a whole number);

OR

Yarn strength index (YSI) / Yarn strength index (YSI) corrected to nominal linear density (correct to a whole number);

OR

Skein breaking tenacity (SBT) / Skein breaking tenacity (SBT) corrected to nominal linear density (correct to a whole number).

ANNEX A

(*Clauses* 5.2 *and* 6.1)

PREPARATION OF SKEINS

A-1 APPARATUS

A-1.1 A wrap reel having a girth of 1.372 m (1.5 yd) or 1 m shall be used to reel off the skeins. The wrap reel shall be fitted with thread guides fixed on a horizontal bar which has a traverse of about 25 mm. The wrap reel shall also be provided with a counting device to indicate the length of yarn reeled out and a bell to ring just before the last revolution or a reel that automatically stops after the required number of revolutions.

A-2 PROCEDURE

A-2.1 Mount a test package on the wrap reel. Pass the end through the thread guides taking care that the yarn shall be kept under sufficient tension to avoid kinks, curls and slack in the yarn on the one hand and stretch on the other (*see* Note) and lead it to the reel.

NOTE — If necessary, the yarn may be wound full one turn around the thread guide

A-2.2 Start the wrap reel. Running it at uniform speed, reel out a skein of required length. Cut and tie the trailing end of the skein to its leading end.

ANNEX B

(*Note Under* 4.4)

SKEIN GAUGE

B-1 APPARATUS

B-1.1 The gauge consists essentially of two round metal pegs of about 1.25 cm diameter and 5 to 6 cm long, located in the same vertical plane. One of the pegs is fixed to the rigid frame of the instrument and the other is carried on the lever of a simple loading system, the fulcrum of which is a low-friction bearing, which is also carried on the frame. At least one of the pegs should be free to rotate about its axis.

B-2 PROCEDURE

B-2.1 Place the skein without bunching, around the two pegs, and apply the appropriate load, for example, by hanging a weight on the end of the lever arm or by moving a sliding weight along the lever arm. The girth of the skein is indicated on a scale attached to the frame of the instrument, by a pointer attached to the lever arm or by an index line on the end of the lever arm. If L is the actual girth of the wrap reel, d the diameter of the pegs, and D the distance between the axes of the pegs when the indicator registers on the scale the actual girth of the wrap reel, then:

$$D = \frac{L}{2} - \frac{\pi d}{2}$$

ANNEX C

(*Clauses* 7.2.1, 7.3.1 *and* 7.3.2)

CORRECTION FOR NOMINAL YARN COUNT/LINEAR DENSITY

C-1 To obtain the average breaking load corrected to nominal yarn count or linear density, use the following procedure.

C-1.1 Arrange the values of linear density and the corresponding breaking load of all the observations as obtained in 6, in the ascending order of the yarn count/ linear density.

C-1.2 Find the average linear density and the average breaking load of:

	Indirect System		*Direct System*		
				50 m skein	100 m skein
The first three skeins	N_{e1}	L_1'	t_1	L_2'	L_3'
The last three skeins	N_{e2}	L_1''	t_2	L_2''	L_3''
All the skeins	N_e	L_1	t	L_2	L_3

C-1.3 Calculations

a) $K_1 = \dfrac{L_1'-L_1''}{N_{e2}-N_{e1}}$

b) K_2 (50 m skein) $= \dfrac{L_2''-L_2'}{1/t_1 \quad 1/t_2}$

c) K_3 (100 m skein) $= \dfrac{L_3''-L_3'}{1/t_1 \quad 1/t_2}$

C-1.4 Find the average breaking load corrected (L, L_{2c}, or L_{3c}) to nominal count N_e' or to nominal linear density t', by the following formulae:

a) $L_{1c} = L_1-K_1\,(N_e'-N_e)$

b) $L_{2c} = L_2-K_2\,(1/t-1/t')$

c) $L_{3c} = L_3-K_3\left(\dfrac{1}{t}-\dfrac{1}{t'}\right)$

ANNEX D

(*Note Under* 7.3.2)

CONVERSION OF BREAKING LOAD VALUES

D-1 To convert observed breaking load value, in lb, of a lea of 109.73m (120 yd) into breaking load, in kg of a skein (100 m) use the following empirical formula:

$$L_1 = 0.584\,8\,L_2 + 0.500\,0$$

where

L_1 = breaking load, in kg, of skein made on a 1-m reel; and

L_2 = observed breaking load, in lb, of lea made on a 1½ yd reel.

NOTE — The formula has been derived from the data collected at the Cotton Technological Research Laboratory (ICAR), Mumbai on 77 samples of yarn of various counts ranging from 14s to 120s.

DETERMINATION OF BREAKING LOAD AND ELONGATION AT BREAK OF SINGLE STRAND

(*Source* : **IS 1670 : 1991**)

1 SCOPE

1.1 It prescribes procedure for determination of breaking load and elongation at break of yarn using constant-rate-of-traverse,constant-rate-of-loading and constant-rate-of-extension machines. Since for any fibre type breaking load is approximately proportional to the linear density, strands of different sizes are compared by converting the observed breaking load to breaking tenacity (centinewtons or millinewtons per tex).

1.1.1 The method prescribed is applicable to monofilaments and multifilaments other than tyre cords and industrial yarns, and spun yarns (single, plied or cabled) made from all kinds of textile fibres of their blends with the exception of yarns that stretch more than 5.0 percent when tension is increased from 0.5 to 1.0g (5 to 10mN) per unit linear density of the yarn in tex.

1.1.2 This method is designed primarily for yarn in package form but can be used for single strands removed/extracted from a woven/knitted fabric.

1.1.3 This method does not cover textured yarns and fancy yarns.

1.1.4 This test method offers two options with respect to moisture content of the specimens at the time of testing.

1.1.4.1 *Option* 1

Conditioning to moisture equilibrium in the standard atmosphere for testing textiles (*see* IS 6359:1971 given in Section B-1/1).

1.1.4.2 *Option* 2

Testing in wet condition. Tests on wet specimens are usually made only on yarns which show a less strength when wet or when exposed to high humidity, for example, yarns made from animal fibres and man-made fibres based on regenerated and modified cellulose. Wet tests are made on flax yarns to detect adulteration by failure to gain strength.

1.1.5 This method also offers three options for the physical confirmation of the specimen.

1.1.5.1 *Option A* — Straight (*see* Note 4).

1.1.5.2 *Option B* — Knotted (*see* Notes 1, 2 and 3).

1.1.5.3 *Option* C — Looped (*see* Notes 1 and 3).

NOTES

1 The reduction in strength due to the presence of a knot or loop is considered a measure of brittleness of yarn. If a textile yarn is looped or knotted, its tensile strength may reduce. This can arise when a yarn is bent to a small radius of cuvature (as in sewing or knitting) or knotted (as in the manufacture of nets). In order to assess the importance of these effects, loop strength and knot strength are described

2 The knot strength test as described in this method is not intended to assess the effciency of any given type of knot for joining together two separate lengths of yarns.

3 Elongation in a knot or loop test is not known to have any significance and is not usually recorded.

4 Unless otherwise indicated, 'single-strand strength' is assumed to refer to a straight, conditioned specimen (*see* **1.1.4.1** and **1.1.5.1**).

2 PRINCIPLE

The specimen is gripped between two clamps of the tensile testing machine and continually increasing load is applied longitudinally by moving one of the clamps until the specimen ruptures. Values of the breaking load and elongation at break of the test specimen are read directly or from a chart attached.

3 TERMINOLOGY

For the purpose of this method, the following definitions shall apply.

3.1 Elongation (or Extension) at Break

In a tensile test, the difference between the length of a stretched specimen at breaking load and its initial length usually expressed as percentage of the latter.

3.2 Elongation at Rupture

The elongation occurring at the final rupture of the specimen. The elongation at rupture is usually but not always, identical with the elongation at the breaking load

3.3 Knot Breaking Load

The breaking load of a strand with a knot tied in the portion of the specimen between the clamps.

3.4 Loop Breaking Load

The breaking load of a specimen consisting of two length of yarn or monofilament from the same package looped together so that one length has both its ends in one clamp of the testing machine and the other length has both its ends in the other clamp.

3.5 Single-Strand Breaking Load

The breaking load of a single strand of yarn, monofilament or cord, not knotted or looped but running straight between the clamps of the testing machine.

4 SAMPLING

The sample shall be drawn according to the procedure given in the relevant material specification or as agreed to between the buyer and seller.

5 CONDITIONING OF TEST SPECIMENS

5.1 Option 1: Conditioned Specimens

5.1.1 Prior to test, the specimens shall be conditioned to moisture equilibrium in the standard atmosphere of 65 ± 2 percent relative humidity and 27 ± 2°C temperature [(*see* IS 6359 : 1971 'Methods of conditioning of textiles') (*see* Section B-1/1)].

5.1.2 When the test specimens have been exposed to standard atmosphere for at least as much time as given below in such a way as to expose as far as possible, all portions of the specimens to the atmosphere, they shall be deemed to have reached moisture equilibrium:

Equilibrium Moisture Regain Value of the Yarn at Standard Atmosphere	*Time* hours
Percent	
Less than 4	6
From 4 to 10	12 to 24
Above 10	24 to 48

5.1.3 The test shall be carried out in standard atmosphere (*see* **5.1.1**).

5.2 Option 2: Wet Specimens

Reel a short skein from each of the packages forming the test sample. Clamp a group of specimens by both ends to prevent loss of twist and submerge them in distilled or demineralised water at room temperature until they are throughly soaked and sink under their own weight. The time of immersion must be sufficient to wet out the specimens thoroughly. The time period will be at least 2 minutes for regenerated cellulose yarn and at least 10 minutes for acetate. For yarns that do not readily wet with water, such as those treated with water repellent or water-resistant materials, add a 0.1 percent solution of a nonioinic wetting agent to the water-bath. Do not use any agent that will affect the physical properties of the yarn appreciable. If a wetting agent has been used, the specimen must be throughly rinsed in distilled or demineralized water before conducting the test. When using option 2B, tie the knots very loosely before wetting in order to save time and to avoid handling while transferring the specimens from container to the testing machine.

6 APPARATUS

6.1 Testing Machine

A single-strand tensile testing machine working on one of the following principles:

a) Constant-rate-of traverse (CRT),

b) Constant-rate-of loading (CRL), and

c) Constant-rate-of-extension (CRE).

6.1.1 It may be noted that, in most cases the results obtained on one type of machine will differ from those obtained on another type and the three types of testing machines will not necessarily given the same results for any given yarn.

6.1.2 Breaking load decreases slightly as the time-to-break increases. The rate of change is approximately of the order of 5 to 10 percent decrease in the breaking load for a ten-fold increase in the time to break. It is assumed that by testing with a specified time-to-break, any difference between the results is reduced to a minimum.

6.1.3 The specimens shall break within 20 ± 3 seconds in the case of constant-rate-of loading and constant-rate-of-extension machines. In the case of constant-rate-of-traverse machines, the rate of traverse shall be 300 ± 15 mm/min and the load range of the machine shall be such that the observed value lies between 10 and 90 percent of the full scale load. The permissible error in the machine at any point in this range shall not exceed ±1 percent of the load.

6.1.4 A variable-speed drive, change gears or interchangeable weights are required to obtain a constant time-to-break of 20 ± 3 seconds. If the rate of operation is adjusted in steps, the steps should not be greater than 1.25 : 1.00.

6.1.5 The machines shall be provided with the following arrangements:

a) Two clamps to grip the specimen, provided with a mechanical or pneumatic device so constructed that through its means it is possible to secure a specimen firmly between the jaws of the clamps so that it does not slip during the test. Also, the edge of the surface of each jaw as well as the jaw lining shall be such that it would not cut or damage the specimen during testing.

When specimens cannot be satisfactorily held with unlined flat-faced jaws, then lined jaws or, if necessary, capstan, drum, bollard clamps or snubbing type jaws may be used.

With some yarns these devices may be necessary in order to reduce the clamping pressure required to prevent slippage; otherwise the clamping pressure will have to be so great that jaw breaks would be frequent.

NOTES

1 Flat-faced clamps are usually used with fine yearns and the snubbing type clamps with high strength yarns or coarse yarns and when specimens slip in the clamps or the number of breaks at or close to the jaws exceeds statistical expectation. To check slippage, make a mark on the specimen as close as possible to the back of each clamp, operate the machine to break the specimens and observed whether the marks have been pulled towards or between the jaw faces of either clamp

2 For sewing threads or similar yarns, clamps described as follows may be used:

For yarns of linear density up to 320 tex, use an inverted screw type clamp (Fig 1) or pulleys with locking devices (Fig 2) or pins For yarns of linear density of 320 tex or higher, clamps of vice type (Fig 3) may be used. With these clamps, specimen length is not determined precisely and consequently measurements of extension are not accurate and therefore the results should not be compared with those obtained with unlined flat jaws

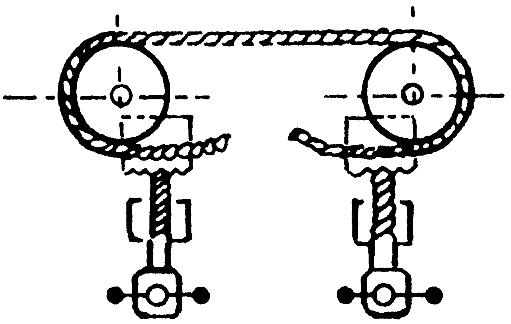


FIG. 1 INVERTED SCREW TYPE CLAMPS

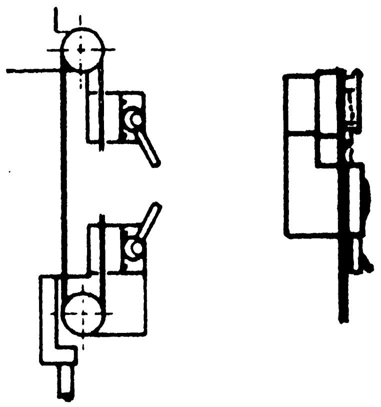


FIG. 2 PULLEYS WITH LOCKING VICES

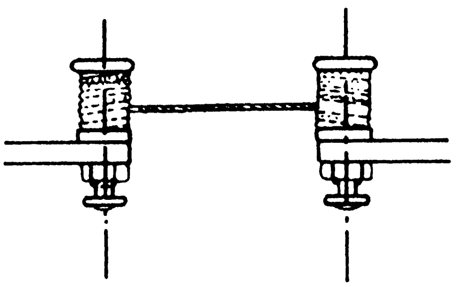


FIG. 3 CLAMPS OF VICE TYPE

b) Means for applying specified pre-tension to the specimen when clamped (the tension device may be a dead-weight, a spring, on an air-actuated mechanism).
The pre-tension shall be as follows:

1) For conditioned specimens – 0.50 ± 0.05 cN/tex., and

2) For wet specimens – 0.25±0.03 cN/tex.

NOTE — This tension should not stretch the specimen more than 0.5 percent, otherwise a mutually acceptable lower tension should be applied

c) Means for adjusting the distance between the clamps.

d) A scale or dial or autograph recording chart graduated so as to give load in cN or N and elongation in millimetres. The error of the indicated or recorded jaw separation shall not exceed 1 mm.

NOTE — Prior to test, care should be take to ensure that the instrument is calibrated

6.1.6 Automatic testing (self-loading and recording) machine may be used provided that it can be operated under specified conditions.

6.2 Container for Wetting Out Specimens

6.3 Holder on Which the Yarn may be Supported Without Tension and Loss of Twist While in Water, for wet specimens only.

6.4 Distilled Water or Demineralized Water

6.5 Nonionic Wetting Agent of Surfactant, for wet specimens only.

7 PROCEDURE

7.1 Set the clamps of the testing machine so that the distance between the nips of the clamps along the specimen axis (including any portion in contact with snubbing surfaces) is 500 ± 2 mm (*see* Notes 1, 2 and 3). With the help of preliminary specimens, set the machine so that the specimen breaks within 20 ± 3 seconds but if the machine is constant-rate-of-traverse type, set it at a rate of traverse of 300 ± 15 mm/min. Take the yarn, discard a first few metres of it, and secure its one end in the jaws of one clamp in such a way that the twist does not change. Place the other end in the other clamp, apply the required pre-tension from this free end to remove any slack or kink without appreciable stretching and secure it in the jaws of the clamp.

NOTES

1 By mutual agreement, the nominal gauge length of 200 ± 1 mm may be used, though under these conditions, results for breaking load are likely to be slightly higher than those obtained with a gauge length of 500 mm.

2 Traditionally the jute trade uses a test length of 610 ± 2 mm for testing of jute yarns

3 Traditionally the silk trade uses a test length of 100 ± 2 mm for testing of silk yarns.

4 In case yarn removed from fabrics is to be tested, a test length of 200 ± 2 mm shall be used.

5 Because of the difficulty of securing the same tension in all the filaments and slippage of the specimen in the clamps, erratic results are frequently obtained with zero twist multifilament yarns unless a small amount of twist is inserted before testing. A twist of 120 ± 10 tpm is usually satisfactory. Twist a specimen about 225 mm longer than the gauge length to be tested.

7.2 Test the adequately conditioned specimens as described in **7.2.1** to **7.2.5** for different options.

7.2.1 *Option* 1: *Conditioned*

Test in the standard atmosphere for testing textiles as specified in **5.1.1**.

7.2.2 *Option* 2 : *Wet*

Test the thoroughly soaked specimens in the normal machine set up or immersed in a tank fitted to the machine. Mount the specimens as described in **7.1** using a pre-tension of 0.25 ± 0.03 cN/tex. Transfer the wet specimens directly from the water-bath to the testing machine and break the specimens at one, and in any case, within 2 minutes after removing them from the water-bath.

7.2.3 *Option* A : *Single-Strand Breaking Load*

Mount the specimen as directed in **7.1** using a pre-tension of 0.50 ± 0.05 cN/tex. Operate the machine, carry the test to rupture and record the breaking load and elongation at break (*see* Note 1). If the specimen slips or breaks in the jaws or breaks within 5 mm from the edge of the jaws, the result shall be discarded and another test specimen taken in lieu thereof.

NOTES

1 In case of jute yarns where elongation tests are carried out separately, 10 tests for elongation may be sufficient.

2 Even if a test value is isolated on account of break near the jaw, the value shall be noted but not taken into account in calculations. If such breaks exceed 10 percent of the number of specimens tested, suitable corrective action on the machine should be taken.

3 Yarns made from blends of combinations of fibres may show elongation beyond the point of maximum load, particularly if one of the components is an elastomeric fibre, when the low elongation components of a yarn are broken, the load falls on the remaining fibres, which continue to elongate until they are broken. Breaking elongations is defined as that corresponding to the maximum load. If elongation continues after the maximum load has been passed, then elongation at rupture may be determined separately

7.2.4 *Option* B : *Knot Breaking Load*

7.2.4.1 Place one end of the specimen in one clamp of the machine, tie a single overhand knot near the middle of the specimen. For a S-twisted yarn (*see* Note), a S-Knot shall be used and for Z-twisted yarn a Z-Knot shall be used (*see* Fig.4 and 5). Place the other end in the second clamp and tighten the clamp.

NOTE — For plied and cabled yarns, the twist direction refers to the final twist.

7.2.4.2 Start the machine and observe and record the breaking load.

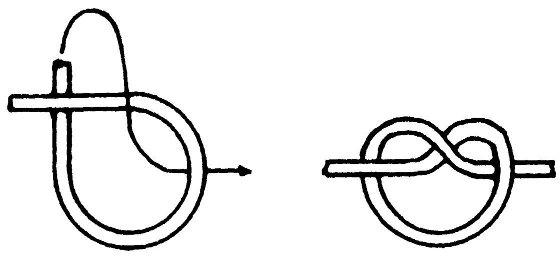

(a) (b)

FIG. 4 Z-KNOT IN Z-TWIST YARN

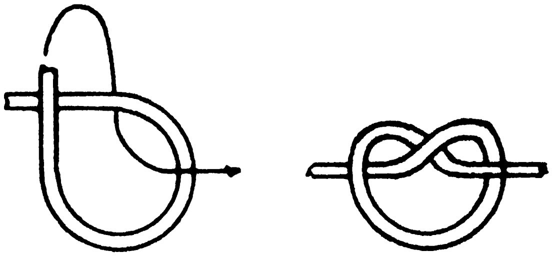

(a) (b)

FIG. 5 S-KNOT IN S-TWIST YARN

7.2.4.3 Repeat the procedure given in **7.2.4.1** and **7.2.4.2** until the required number of specimens have been broken.

7.2.5 *Option C : Loop Breaking Load*

7.2.5.1 Each specimen shall consist of two interlinked looped lengths of yarn taken from one package or end. Secure both ends of one piece in one clamp of the testing machine so that the length of the loop is about one half the gauge length. Pass one end of the second piece through the loop formed by the first, place both ends of the second piece in the other clamp of the machine and close the clamp.

7.2.5.2 Start the machine and observe and record the breaking load.

7.2.5.3 Repeat the procedure given in **7.2.5.1** and **7.2.5.2** until the number of specimens have been broken.

8 CALCULATIONS

8.1 Breaking Load

Calculate the mean breaking load in newtons from all the observed values expressing it into three significant figures. Also calculate the coefficient of variation.

8.2 Elongation (or Extension) at Break (Option A only)

Calculate the mean elongation at break in percent from all the observed values expressing it to two significant figures. Also calculate the coefficient of variation.

8.3 Tenacity

Calculate the tenacity by the following formula:

Tenacity in cN/tex or mN/tex =

$$\frac{\text{Mean breaking load in centinewtons or millinewtons}}{\text{Mean linear density in tex}}$$

NOTE — The linear density of yarn or cord shall be determined from the same package in accordance with IS 570 1964 (*see* Section B-2/6) IS 681 1964 (*see* Section B-2/4) or IS 1315:1977 (*see* Section B-2/2) as the case may be.

9 REPORT

The test report shall include the following:

a) Description of the material tested:
b) Option used, for wet tests the technique used for wetting;
c) Name of the instrument, capacity and load range operated;
d) Mean time to break or rate of traverse:
e) Test length;
f) Type of jaw and jaw faces, if other than flat metal;
g) Number of valid tests performed, number of tests rejected due to jaw breaks;
h) Mean breaking load and coefficient of variation, if required;
j) Mean elongation at break and coefficient of variation, if required; and
k) Mean tenacity.

DETERMINATION OF DRY AND WET TENACITY AND ELONGATION OF MAN–MADE FIBRES CONTINUOUS FILAMENT FLAT YARNS

[*Source* : IS 7703 (Part 2) : 1990]

1 SCOPE

It prescribes methods for determination of dry and wet tenacity and elongation of man-made fibres continuous filament flat yarns.

2 PRINCIPLE

Conditioned specimen or the wet specimen is gripped between the two clamps of the tensile testing machine and a continual increasing load is applied longitudinally by moving one of the clamps until the specimen breaks. Values of elongation corresponding to a predetermined load, maximum breaking strength and elongation at break of the test specimen are noted. Tenacity is calculated by dividing the breaking strength in newton by the linear density in tex and multiplying by 100 and the elongation (percent) by dividing the elongation by the gauge length.

3 SAMPLING

3.1 Sample shall be so drawn as to be representative of the lot.

3.2 Sample drawn in accordance with the procedure laid down in the material specification or as agreed to between the buyer and the seller shall be taken as representative of the lot.

4 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING OF SPECIMENS

4.1 Unless otherwise agreed to between the buyer and the seller for testing of conditioned test specimens, the test sample shall be conditioned to a moisture equilibrium from the dry side in the standard atmosphere (*see* IS 6359:1971 given in Section B-1/1) at 65 ± 2 percent relative humidity and 27 ± 2°C temperature for determination of dry tenacity and elongation.

NOTE — When a test sample under zero tension has been left in such a way as to expose, as far as possible all portions of it to the standard atmosphere for 24 hours, the test sample shall be deemed to have reached a state of moisture equilibrium

4.2 The test shall be carried out in the standard atmosphere (*see* **4.1**).

4.3 For determination of wet tenacity and elongation the sample need not be conditioned in the standard atmosphere.

5 APPARATUS

5.1 Testing Machine

A single strand tensile strength testing machine working on one of the following principles shall be used:

a) Constant-rate-of-traverse (CRT),
b) Constant-rate-of load (CRL), or
c) Constant rate-of extension (CRE).

The specimens shall break within 20 ± 3 seconds in case of constant-rate-of load and constant-rate-of extension machines. In case of constant rate-of-traverse machine the rate-of-traverse shall be 300 ± 15 mm/minute, and the load range of the machine shall be such that the observed values would be between 10 and 90 percent of the full scale load. The permissible error in the machine at any point in this range shall not exceed ± 1 percent. The machines shall be provided with the following arrangements:

a) Two clamps to grip the specimen, each provided with following provisions:
    i) Each clamp of the machine shall be of curved type in which the yarn is gripped between the plain-faced jaws and this makes an half turn round a cylindrical extension of one of the jaws before passing on to the other similar clamp. The cylindrical friction surface shall be between 10 to 20 mm in diameter. An outline of the above type of clamp is shown in Fig. 1. The length of specimen between points A and A' is the test length.
    ii) Each clamps shall be provided with a mechanical or pneumatic device so constructed that through its means a specimen can be secured firmly between the jaws of the clamps so that it does not slip during the test. Also the edge of the surface of each jaw shall be such

test it would not cut or damage the specimen during testing.

b) Means for adjusting the distance between the clamps.

c) Means for applying pretension of 0.5 ± 0.1 cN/tex to the specimen when clamped (tension device may be a dead weight, a spring or an air-acturated mechanism).

d) A scale and dial or autographic chart recorder graduated so as to give load and elongation at predetermined load and at break.

6 PROCEDURE

6.1 Test on Conditioned Specimens for Dry Tenacity and Elongation

6.1.1 Set the clamps of the testing machine so that the distance between the clamps is 250 ± 2 mm or 500 ± 2 mm or as agreed to between the buyer and the seller. With the help of preliminary specimens, set the machine so that the specimen breaks within 20 ± 2 seconds in the case of constant rate of loading or constant-rate-of-extension type machine. In the case of constant-rate-traverse type machine, set the rate of traverse at 300 ± 15 mm/min. Take the yarn from the conditioned sample and discard a first few metres of yarn. Fix one end in the jaws of one clamp in such a way that the twist does not change. Apply the required pre – tension from the free end and secure it in the jaws of the other clamp.

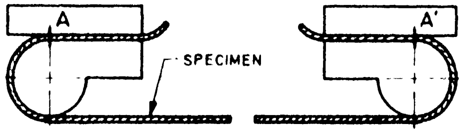


FIG. 1 SCHEMATIC DIAGRAM OF GRIPPING CLAMPS

6.1.2 Operate the machine and carry the test to rupture and record the breaking strength, elongation at predetermined load as required and elongation at break from the load elongation curve of the autographic chart recorder provided.

NOTE — Even if a test value is isolated on account of a break near the jaw, the value shall be noted but not taken into account in calculations. If such breaks exceed 10 percent of the number of specimens tested, suitable corrective action should be taken on the machine

6.1.3 Open both the clamps and remove the broken specimen. Test another test specimen in a similar manner as in **6.1.2** discarding at random several metres of yarn between two successive tests. Perform minimum 10 tests or as agreed to between the buyer and the seller.

6.2 Test on Wet Specimens for Wet Tenacity and Elongation

6.2.1 Take the required number of test specimens either 20 or as agreed to between the buyer and the seller and immerse them in distilled water for at least 2 minutes in case of regenerated cellulose rayon and 10 minutes for acetate rayon (*see* Notes 1 and 2).

NOTES

1 The period of immersion should be sufficient to wet out the specimens thoroughly. Longer periods of immersion would not register further loss of strength if wetting is sufficient. Specimens treated with water-repellent or water-resistant finishes may have to be immersed for prolonged period. For yarns which do not wet out readily with water, a penetrating agent such as neutral soap of a non-ionic wetting agent may be added to the water bath, the amount of the agent used being such as not to exceed that required to obtain maximum rate of wetting out and as not to affect the normal physical properties of the yarn.

2 If number of specimens cling together in the water bath, they should be separated by gently raising and lowering them in water so as to permit a single strand to be drawn out without strain.

6.2.2 Repeat the procedures laid down in **6.1.1** to **6.1.3** for all the specimens to be tested.

7 CALCULATIONS

7.1 Tenacity

Calculate the mean dry or wet breaking strength in newtons from all the observed values and calculate the tenacity as follows:

$$\text{Tenacity in cN/tex} = \frac{\text{Mean breaking strength in newton} \times 100}{\text{Mean linear density in tex}}$$

NOTE — The linear density of yarn shall be determined from the same package in accordance with IS 7703 (Part 1) : 1990 (*see* Section B-2/5).

7.2 Elongation

Calculate the mean elongation at predetermined load as required and also at break in percent from all the observed values.

8 REPORT

The test report shall include the following;

a) Description of the material tested;
b) Type of the testing machine and its capacity;
c) Mean time for break or rate-of-traverse;
d) Specimen length;
e) Number of tests performed;
f) Mean dry or wet elongation at predetermined load, as required;
g) Mean dry or wet elongation at break; and
h) Mean dry or wet tenacity as required.

DETERMINATION OF COMMERCIAL MASS OF MAN-MADE FIBRE CONTINUOUS FILAMENT FLAT YARNS

[*Source* : IS 7703 (Part 3):1991]

1 SCOPE

It prescribes method for determination of commercial mass of consignments of individual man-made fibre continuous filament flat yarns.

2 PRINCIPLE

The net mass of the conditioned yarn at equilibrium with the standard atmosphere for testing may be taken as the commercial mass if agreed to between the buyer and the seller. Alternatively, the commercial mass may be obtained by adding a mass corresponding to the commercial (standard) moisture regain to the oven-dry mass of the consignment.

3 SAMPLING

3.1 Samples shall be so drawn as to be representative of the lot.

3.2 Sample drawn in accordance with the material specification or as agreed to between the buyer and the seller shall be taken as representative of the lot.

4 APPARATUS

4.1 Balance

The balance shall be of sufficient capacity to weigh the specimen required for the purpose and shall be capable of weighing to an accuracy of 1 mg.

4.2 Drying Oven

The oven shall be provided with forced ventilation and shall be capable of maintaining a temperature of 105 ± 3°C. It shall preferably be provided with a weighing balance. In case the drying oven is not provided with a weighing balance, a desiccator with a suitable desiccant and sealed containers of known mass shall be made available.

5 PROCEDURE

5.1 Remove top few layers from each selected sample package and make two skeins of 100 m each and determine the net mass of each at the prevailing atmospheric conditions to an accuracy of 1mg. Determine the average net mass of the skeins (M_n).

5.2 Place the skeins (*see* **5.1**) in the ventilated drying oven maintained at 105 ± 3°C and fed with air from the standard atmosphere. Continue drying until constant mass is attained. The mass shall be taken as constant when the difference between any two successive weighings made at intervals of 20 minutes does not exceed 0.1 percent.

5.3 Determine the mass of each skein sample without removing it from the oven, with the air flow stopped. In case the drying oven is not provided with a weighing balance, remove the test sample from the oven and transfer it into a weighing container of known mass and close the lid tightly. The transfer of the skein shall be done in as quickly as possible. Cool the skein and the container in a desiccator to room temperature before weighing. Determine the mass of each skein and the container and then deduct from this the tare of the container to find out the oven-dry mass of each skein. All weighings shall be correct to 1 mg. Determine the average oven-dry mass of the skeins (M_o).

5.4 Determine the net mass of yarn of each sample container (box) (M_c), correct to 1 g, by deducting the mass of the packing material and the corresponding mass of supports of packages and tare of the container from the total mass. The total mass of the sample container represents the mass of the supports of packages, packing material, the yarn and the container in which the packages are packed.

6 CALCULATIONS

6.1 Calculate the commercial mass in kilograms of each selected container by the following formula:

$$\text{Commercial mass of the material of selected container} = \frac{100 + R}{100} \times \frac{M_o}{M_n} \times M_c$$

where

R = commercial moisture regain percent (*see* Note),
M_o = average oven-dry mass of the yarn skeins (*see* **5.3**),
M_n = average net mass of the yarn skeins (*see* **5.1**), and

M_c – net mass of the material of the selected container (box) (*see* **5.4**).

NOTE – Unless otherwise agreed to between the buyer and the seller, commerical moisture regain values for various man-made fibres as given below may be used

Material	*Commerical Moisture Regain Percent*
(1)	(2)
Polyester	0.4
Polyamide	4.5
Rayon	11.0
Acetate	6.5
Acrylic	1.5
Olefins	zero
Triacetate (primary)	3.5
Glass	zero
Modacrylic	
Class 1	0.4
Class 2	2.0
Class 3	3.0

6.2 Determine the commercial mass of the consignment by the following formula.

$$\text{Commercial mass of consignment} = \text{Net mass of consignment} \times \frac{\text{Commercial mass of the material of the selected container}}{\text{Net mass of the material of the selected container}}$$

7 REPORT

The report shall include the following:

a) The nature and composition of the material;
b) Net mass of the consignment;
c) Commercial mass of the consignment;
d) Commercial moisture regain value used;
e) Product batch number;
f) Name of the manufacturer, and
g) Month and year of manufacture of the material.

DETERMINATION OF CORRECT INVOICE WEIGHT OF ALL WOOL MATERIALS

(*Source* : IS 4902:1981)

1 SCOPE

It prescribes a method for determination of correct invoice weight of all wool tops, yarns and fabrics.

2 SAMPLING

2.1 Lot

The quantity of wool material tops, yarn or fabric purporting to be of one definite type and quality delivered to one buyer against one despatch note.

2.2 Sample drawn in compliance with the specification for the material or as agreed between the concerned parties shall be taken to be representative of the lot. Prepare test sample as given in **2.2.1** to **2.2.3**.

2.2.1 *Tops*

If the wool is in the form of tops, a length of about one metre shall be removed from each top after discarding end portion. The material taken from different tops shall be thoroughly mixed and a test sample of about 200 g shall be drawn by suitable method.

2.2.2 *Yarn*

a) If the yarn is in the form of cops, bobbins, tubes, pirns or other primary packages, the sample shall be divided into two parts. From the top portion of each package in the first part of the sample and from about half way through each package in the second part of the sample, a length of yarn shall be reeled off so that *firstly* the lengths of yarn reeled off from the various packages are approximately equal in weight and *secondly* their total weight is approximately 200 g.

b) If the yarn is in the form of cones, cheeses or other large packages, from each package in the sample, two lengths of yarn, one from the outer portion of the package and another from near the middle portion shall be reeled off so that. *firstly* the lengths of yarn reeled off from the various packages are approximately equal in weight and *secondly* their total weight is approximately 200 g.

c) The length of yarn obtained as in (a) or (b) above, shall constitute the test sample.

2.2.3 *Fabrics*

From different portion of the fabric sample(s) cut 3 or 4 sample square pieces of approximately equal size, their total weight should be about 200 g. This shall constitute the test sample.

3 APPARATUS

3.1 Drying Oven

Preferably of the ventilated type, capable of maintaining an inside temperature of 105 ± 3°C.

3.2 Weighing Balance

Capable of weighing accuratgely to 0.000 1g.

3.3 Soxhlet Apparatus

With auxiliaries like beaker, weighing flasks, etc.

4 REAGENTS

4.0 Quality of Reagents

Unless specified otherwise, pure chemicals shall be employed in tests and distilled water shall be used where the use of water as reagent is intended.

NOTE – 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the test results

4.1 Benzene

Specific gravity 0.879 0 (*see* IS 1840:1961 'Benzene, reagent grade').

4.2 Methanol

Specific gravity 0.791 7 [*see* IS 517:1967 'Methanol (methyl alcohol) (*second revision*)'].

5 PROCEDURE

5.1 Determine the weight of the consignment (*w*). From the test sample of 200 g, take a test specimen weighing about 10 g and put it in a polyethylene bag of known weight, and seal it in the environment in which the consignment is housed. Weigh the bag and find the weight of the test specimen (W_g). Take care to see that no change in the moisture content of the test specimen takes place during the drawing and weighing of the sample.

5.2 Take the test specimen and wrap it in a filter paper. Extract the specimen with the 300 ml of benzene methanol mixture [3 : 2 (*v/v*)] in a soxhlet apparatus for three hours, siphoning the solvent at a minimum rate of 6 extractions per hour. Remove the test specimen and dry it to constant weight in an oven at a temperature of 105 ± 3°C. Determine the weight of the dried extracted specimen (W_o).

5.3 Repeat the test with one more test specimen.

6 CALCULATION

6.1 Calculate the correct invoice weight of the consignment by the following formula:

$$W_c = W \times \frac{W_o}{W_s} \times \frac{100 + R}{100}$$

where

W_c = correct invoice weight of the consignment,
W = original weight of the consignment,
W_o = oven dry weight of the deoiled specimen,
W_s = original weight of the specimen, and
R = commercial moisture regain value (*see* Note).

NOTE — For the commercial moisture regain values reference to IS 7033:1973 'Commercial moisture regain values for wool and its products' shall be made.

6.1.1 Calculate the correct invoice weight of the consignment by using the formula given in **6.1**.

6.2 Calculate the average of the two values obtained as in **6.1** and **6.1.1**, if the difference between the two is not more than 0.5 percent.

7 REPORT

The report shall include the following information:

a) Type of material;
b) Invoice weight of the consignment;
c) Commercial moisture regain values used; and
d) Correct invoice weight of the consignment.

DETERMINATION OF UNEVENNESS PERCENTAGE OF CONTINUOUS FILAMENT POLYESTER AND POLYAMIDE FLAT YARN

[*Source* : IS 7703 (Part 5):1987]

1 SCOPE

1.1 It prescribes a method of test for determination of short-term variations in mass per unit length (unevenness percentage) of continuous filament polyester and polyamide flat yarn.

1.2 This method covers the indirect measurement of unevenness of the flat yarn by means of continuous runs on a suitable Uster unevenness testing instrument. The direct procedure for measuring unevenness by cutting and weighing short lengths of a flat yarn is not covered by this standard.

1.3 Low twist filament yarns should be tested after the yarn is pretwisted while testing.

2 TERMINOLOGY

2.1 Unevenness

Variation in the linear density of a continuous yarn or a portion of a yarn (*see also* coefficient of variation unevenness, mean deviation unevenness).

2.2 Coefficient of Variation Unevenness, CV Percent

The standard deviation of the linear densities over which unevenness is measured expressed as a percentage of the average linear density for the total length within which unevenness is measured (*see also* unevenness, mean deviation unevenness).

2.3 Mean Deviation Unevenness, U Percent

The average of the absolute value of the deviations of the linear densities of the integrated lengths between which unevenness is measured and expressed as a percentage of the average linear density for the total length within which unevenness is measured (*see also* unevenness, coefficient of variation unevenness).

2.4 Length Between, L_b

The length between which unevenness is measured, the equivalent of the length of yarn segments weighed in a direct method of measuring unevenness.

2.5 Length Within, L_w

The length over which unevenness is measured, the total length of the yarn from which the segments weighed were sampled in a direct method of measuring unevenness. For indirect methods, the maximum value of length within is the tested length from the specific package.

2.6 Unit Length of Instrument, L_u

The length of yarn being measured between the sensing elements any moment.

2.7 Integrator

A device that calculates the coefficient of variation of unevenness or the mean deviation unevenness.

2.7.1 The term 'integrator' and 'integration' as applied to textile unevenness testing do not imply integration in the strict mathematical sense. The type of integrator, linear or quadration must be carefully selected depending upon a known irregularity of the material, that is, purely random or purely periodic.

2.8 Quadratic Integrator

An integrator that operates continuously and reports unevenness for the time during which it has been active, giving equal weight to all portions of the input (compensated-memory integrator).

2.9 Linear Integrator

An integrator that operates continuously and reports unevenness for a certain, and unchanging, time past.

The input to the integrator immediately preceeding the moment of taking a reading receives greater 'weight' than the prior input, and this 'weighting' gradually decreases with the lapse of time (fading memory integrator).

3 PRINCIPLE AND LIMITATIONS

3.1 A yarn is passed through the sensing device of an Uster unevenness tester at constant speed and a momentary value proportional to the linear density of the yarn is recorded. The Uster instruments are equipped with an integrator that calculates the unevenness automatically and the value is read while the yarn is passing through the instrument after 400 m of yarn have been tested.

3.1.1 The variation of one specific property, linear density, is termed unevenness. The method is concerned with measuring the unevenness of flat yarn.

3.1.2 Unevenness is always expressed as between successive lengths and over a total length. When the length between which unevenness is measured (L_b) is very short 8 mm of yarn), then reference is often made to short-term unevenness.

3.1.3 Unevenness can be measured by direct method or indirect methods. The direct method consists of cutting and weighing yarn segment of length L_b and is the reference method of determining unevenness. Unevenness testing instruments, as covered in this standard, use the indirect method where unevenness is determined by the measurement of yarn properties closely related to and dependent on linear density. The accuracy of the indirect method and of an instrument utilizing it can be judged by a comparison of the value of unevenness it gives with one obtained by the direct method of cutting and weighing.

3.1.4 The Uster unevenness testing instruments measure those properties of the yarn which change the capacitance when the yarn passes between the plates of a capacitor.

3.1.5 A number of mathematical concepts are used to express the unevenness of yarn. They are all based on the coefficient of variation or its square. There is, therefore, some advantage in using an unevenness testing instrument that gives the coefficient of variation and there by fits into the general mathematical scheme.

4 APPARATUS

4.1 Capacitance-Type Unevenness Testing Instrument

A suitable Uster unevenness tester using automatic integrator or any other suitable instrument which can satisfy the requirements. The instrument shall have the following accessories provided.

4.1.1 *Package Holders, Guides, Tension Devices and Take-up Mechanism*

Which allow for or assist in, uniform delivery of the yarn at the specified speed without undue acceleration or deceleration and at a reasonably constant tension.

4.1.2 *Recorder*

To give a permanent chart record of the test details and to depict the unevenness. It is a means to record all unevenness.

4.2 Pretwisting with constant tension material feeding facilities for low-twist filament yarns to impart false-twist into low-twist filament yarn while it passes between the sensing elements at a uniform tension.

5 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING OF SAMPLE

5.1 The test sample shall be conditioned to a state of moisture equilibrium from dry side in standard atmosphere at 65 ± 2 percent relative humidity and 27 ± 2°C temperature (*see* IS 6359:1971 given in Section B-1/1) and tested in the same atmosphere.

NOTE — When a test sample has been left in such a way as to expose as far as possible, all portions of it to the standard atmosphere for 24 hours, the test sample shall be deemed to have reached a state of moisture equilibrium.

6 PROCEDURE

6.1 Calibrate the unevenness testing instrument as prescribed by the instrument manufacturer.

NOTE — Do not separate the length of yarn to be tested from the packages prior to testing.

6.2 Mount the package on a suitable holder. Thread the free end of the yarn through the sensing elements of the tester and through the take-up mechanism. If a low twist yarn is to be tested, pass it through a device imparting false twist.

6.3 Set the take-up mechanism to yarn speed of 100 m/min or to speed of travel as agreed to between the buyer and the seller. If a recorder is used, set the yarn to chart speed 10 cm/min with test time limited to four minutes.

6.4 Start the take-up mechanism of the tester and recorder, if used. Adjust the controls of the tester to record on the central part of the recorder chart or on the central part of the insturment meter or both.

6.5 Turn on the integrator. Test a total yarn length of at least 400 m in one uninterrupted run, unless otherwise agreed upon by the purchaser and the seller. Record the meter unevenness value.

6.6 Follow the unevenness tester instruction manual for operational procedures not outlined in this method.

7 CALCULATIONS

7.1 The CV percentage and U percentage can be estimated from the chart by converting the line of the record into a frequency distribution. U percentage can also be estimated by the use of a planimeter. Normally, however, CV percentage or U percentage will be read from the integrator (*see* **6.5**).

7.2 If more than one values of CV percentage or U percentage is obtained for individual packages, then calculate arithmatic mean of values of unevenness for each package.

7.3 Calculate the average of CV percentage of U percentage for all packages.

7.4 If required, claculate the coefficient of variation or the standard deviation (or both) of the CV percentage or U percentage values obtained for each package.

8 REPORT

8.1 State that the specimens were tested as directed in the standard. Describe the material or product sampled.

8.2 Report the following information.

8.2.1 Number of specimens tested.

8.2.2 Instrument used and type of integrator, if used.

8.2.3 Yarn travel speed.

8.2.4 Length of specimen tested.

8.2.5 Chart speed or yarn to-chart speed ratio and method of chart calculation, if chart is used.

8.2.6 Type of setting used, that is, normal, inert or half inert.

8.2.7 Atmospheric conditions used, if not standard.

8.2.8. Average value of unevenness obtained as CV percentage or U percentage .

8.2.9 Coefficient of variation or standard deviation, or both, if calculated.

8.2.10. The values of length between L_b and length within L_w.

NOTE The preferred way of writing the unevenness is to put L_b and L_w values in parentheses (L_b, L_w) after CV percentage or U percentage

Example —CV (8 mm, 100 m) to be read as follows:

'Coefficient of variation unevenness between 8 mm lengths within 100-m lengths'.

GRADING FOR APPEARANCE OF COTTON YARN USING PHOTOGRAPHIC STANDARDS

(*Source* : IS 13260:1993)

1 SCOPE

It prescribes a method of grading for appearance of single cotton yarn, carded or combed, with the use of BIS Photographic Cotton Yarn Appearance Standards.

2 TERMINOLOGY

For the purpose of this method, the following definitions shall apply.

2.1 Appearance Grade

The appearance of cotton yarn in the grey state evaluated by visual comparison of black-board wrappings of yarn with photographic standards and based on the assessment of regularity, freedom from imperfections, foreign matter, neppiness and lack of hairiness.

2.2 Fuzz

Untangled fibre ends that protude from the surface of yarn.

3 SAMPLING

3.1 To test conformity of a lot to a specification as regards appearance grade, samples shall be selected so as to be representative of the lot in accordance with the relevant material specification or in accordance with IS 3920:1985 as given in Section A-1/1.

3.2 The number of packages to be taken at random from each selected bale (or case) shall be such that a total number of five packages are drawn from the lot. As far as possible, equal number of packages shall be drawn from each bale. However, there may be a need for drawing additional packages.

3.3 One board shall be prepared from each of these five packages.

4 EQUIPMENT

4.1 Yarn Board Winder

This is a manually operated or motor-driven machine used for winding yarn on the thermo-setting resin bonded laminate black board by rotating the clamped board end over end. The equipment is also fitted with a traversing guide to advance the yarn across the board as it is wound. The machine shall be capable of spacing the yarn evenly at the rate of 8, 10, 13, 15 and 19 wraps per cm (20, 26, 32, 38 and 48 wraps per inch) on the board with a tolerance of ± 10 percent.

NOTE It should be ensured that the wraps per cm is within the limits of tolerance as the spacings of the yarn on the black board have an important bearing on the assessment made. This is due to the fact that more closely wounded yarn will have larger length for view on the board and consequently more imperfections per unit area. Obviously the effect will be opposite if the spacings are wider on the board

4.2 A cabinet provided with arrangement for proper illumination, for mounting the black-board wrappings and the BIS Photographic Cotton Yarn Appearance Standards (SP 54) to evaluate the appearance grade of yarn.

4.3 The black-board laminate black-boards with dull finish on both sides on which yarn can be wound to cover an area of approximately 140 mm × 250 mm.

4.4 BIS Photographic Cotton Yarn Appearance Standards (SP54)

A set of BIS Photographic Cotton Yarn Appearance Standards consists of five series, covering five ranges of yarn counts (*see* Table 1). Each series has four photographs representing grades, A, B, C and D. Grade A is the highest and others are progressively lower. The range of counts covered by each series is given in Table 1.

NOTE — SP 54 is available for sale in BIS offices

Table 1 Requirements for the Preparation and Assessment of Yarn Boards
(*Clause* 4.4)

BIS Photo graphic Cotton Yarn Appearance Standards Series	Count Range		Count of Yarn Used for Board Preparation		Wraps per cm (Per inch)
	tex	Ne	tex	Ne	
BIS 1	100 to 37 +	6+ to 16"	60	10	8 (20)
BIS 2	37 to 18.5+	16 + to 32"	30	20	10(26)
BIS 3	18.5 to 12 +	32 + to 50"	15	40	13(32)
BIS 4	12 to 7.9 +	50 + to 75"	10	60	15(38)
BIS 5	7.9 and below	75 + and above	6	100	19(48)

NOTE—For assessing the appearance grade of yarn sample whose count value falls within the range of 6.0 Ne to 16.9 Ne (100 to 37 + tex), boards prepared at 8 wraps per cm (20 wraps per Inch) should be assessed using BIS 1. For yarn samples having mean count values in the other ranges, boards are to be prepared and assessed using the respective standards boards as given in Table 1

5 DESCRIPTION OF YARN GRADES

5.1 Grade A Yarn

Grade A yarn may have no large neps which are over three times the normal diameter of the yarn and very few small ones. Grade A yarn should have good centimetre-to centimetre uniformity and good cover without excessive fuzziness. No lead nor other foreign matter may be present in Grade A yarn.

5.2 Grade B Yarn

Grade B yarn may have no large neps, but may have a few small ones. Grade B yarn may have no more than three small pieces of foreign matter per board or specimen provided they do not form slubs. Grade B yarn may be slightly more irregular any may have slightly more fuzz than a Grade A yarn.

5.3 Grade C Yarn

Grade C yarn may have more neps, and larger ones as well as more fuzziness and a greater amount of foreign matter than Grade B yarn. The contrast between the thick and thin places and the normal diameter of the yarn may be greater than in Grade B yarn resulting in an overall rougher appearance.

5.4 Grade D Yarn

Grade D yarn may have some slubs that are more than three times the average diameter of the yarn. Grade D yarn may have more neps, neps of a larger size, more thick and thin places, more fuzz and more foreign matter than Grade C yarn. When slubs or large neps are present, Grade D yarn may have fewer neps than Grade C yarn. Grade D yarn may have an overall rougher appearance than Grade C yarn.

5.5 Yarn Below Grade D

Yarn below Grade D may have more defects and an overall rougher appearance than Grade D yarn.

6 PROCEDURE

6.1 Set the winding device so as to obtain the required number of threads per cm on the black-board, depending upon the count range in which the yarn under test falls (*see* Table 1). Take one of the packages constituting the test sample and mount it on the winding device. Also mount the black-board on the device in such a way that yarn wound on it will lie along the length of the board covering an area of approximately 140 mm × 250 mm. In a similar manner prepare remaining black-board wrappings, taking for each black-board one package from the test sample.

6.2 Mount one of the black-board wrappings in the cabinet and by comparison with series of the BIS Photographic Cotton Yarn Appearance Standards relevant to the count of yarn under test, mounted in the same cabinet, evaluate the appearance grade of yarn on the black board as A, B, C or D. Assess both sides of each black-board wrapping and assign the grade of the poorer side only as the grade of the specimen.

While assigning the grade of the black-boards it should be noted that slubs, thick places, neps and foreign matter are to be treated as worst defects. Yarns with slubs should not be assigned A or B grade.

6.2.1 It is preferable to get the assessment of the appearance grade of each black-board wrapping by a minimum of three observers.

6.2.2 In case the black-board wrapping does not precisely conform to any of the above mentioned standard grades, namely, A, B, C, D but falls in between two consecutive grades, denote the appearance grade of the yarn by '+' mark after the letter designating the lower of the two grades.

6.2.3 In case the black-board wrapping appears poorer than Grade D, denote the appearance grade of the yarn as '<D' (Below D).

6.3 Following the procedure given in **6.2**, evaluate the appearance grade of the remaining black-board wrappings.

6.4 If the observers differ by more than one grade, five more packages may be drawn and evaluated.

7 CALCULATION

7.1 In acceptance testing, if no specimen falls more that one grade below that specified, determine the percentage of specimens that are equal to or better than the specified grade. If 80 percent of the specimens graded are equal to or better than the specified grade, and remaining 20 percent do not fall below the next lower grade consider the lot as passing yarn appearance specification. If one or more specimens fall more than one grade below that specified, reject the lot.

7.2 For research and experimental purposes, convert the yarn appearance grade of all the five grades of each of the graders to their respective appearance index values using Table 2 and calculate the individual grader's average index. From the average index values of all the graders, calculate the average index value of the yarn sample, correct to an integer.

Table 2 Conversion of Grade into Appearance Index

Grade (1)	Appearance Index (2)
A and above	130
B +	120
B	110
C+	100
C	90
D+	80
D	70
Below D	60

8 REPORTS

The test report shall include the following:

a) Count of yarn as indicated on the package;
b) Number of black-board wrappings examined;
c) Average appearance index and appearance grade of the yarn in the lot;
d) Range of grades; and
e) Series number of the BIS Photographic Apearance Standards used for grading the sample.

DETERMINATION OF LENGTH AND WIDTH OF WOVEN FABRICS

(*Source* : IS 1954:1990)

1 SCOPE

1.1 It prescribes two methods for determination of length and width of pieces (of any length) of all kinds of woven fabrics that are in the state of relaxation obtained by exposure (free from applied tension) to the standard atmosphere.

1.2 The methods are applicable to woven fabrics (including 'stretch' fabrics) made up full width of folded down the middle.

2 TERMINOLOGY

2.1 Length of Piece

The distance between the outermost complete weft thread in a piece, other than weft threads of other materials at the end(s) of the piece.

2.2 Width of Piece

2.2.1 Overall Width

The distance, at right angles to the length of the fabric, between the outermost warp thread in a piece.

2.2.2 *Width Between Lists or Selvedges* (*Usable Width*)

The distance at right angles to the length of the fabric, between the outermost warp thread of the body of the fabric.

3 APPARATUS

3.1 Calibrated Steel Rule of length at least 2 m (preferably 3 m), and graduated in centimetres and millimetres.

3.2 Table having a smooth flat surface, of width greater than that of the fabric when prepared for measuring, and of length at least 4 m.

NOTE — If a table of substantially greater length is used, the distance between temporary marks (*see* 6.2.1 and 6.2.3) may also be increased.

4 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

4.1 The fabric pieces shall be conditioned to moisture equilibrium in the standard atmosphere of 65 ± 2 percent relative humidity and 27 ± 2°C temperature from the dry side (*see also* IS 6359:1971 given in Section B-1/1).

NOTE — The strain imposed during manufacturing and finishing may appreciably affect the length and width of fabrics, and some recovery may take place during storage. It is, therefore, advisable for fabrics to remain unrolled and freely exposed for as long as possible in order to allow for relaxation before taking measurements. Fabrics containing threads of rubber may require a period not less than four days for relaxation.

4.2 The testing of fabric pieces shall be carried out in the standard atmosphere (*see* **4.1**) or prevailing atmosphere depending upon the method used.

5 SAMPLING

Sample from the lot shall be drawn so as to be representative of the lot. Sample drawn in accordance with the relevant material specification or as agreed to between the buyer and the seller shall be representative of the lot.

6 DETERMINATION OF LENGTH

6.1 Location of Marks and Measurements

6.1.1 *Fabric Made up Full Width*

Measure and mark the fabric along two lines, each positioned at a distance of about one-quarter of the width of the fabric from the adjacent selvedge.

6.1.2 *Fabric Folded Down the Middle*

Measure to the nearest millimetre and mark one side of the fabric along a line approximately half-way between the selvedge and the fold, then turn the fabric over and mark and measure the other side in a similar manner.

NOTE — Pieces of width less than that of the measuring table may be opened and measured as described in 6.1.1.

6.2 Method 1

6.2.1 *Preliminary Markings*

Place the piece on the table (at full width,folded down the middle if received in this state) so that the first 3 to 4 m portion lies flat and free from applied tension, and make temporary marks (used only to determine completion of relaxation and conditioning) 3 m or 2 m apart, near the end of the piece. Then draw the fabric gently along the table until the middle portion of the piece lies flat and free from applied tension, and make a second pair of temporary marks. Finally draw the remainder of the fabric gently along the table until the last 3 to 4 m portion lies flat and free from applied tension, and make a third pair of temporary marks.

6.2.2 *Conditioning*

With the fabric so arranged that it is free from applied tension and its surfaces are freely exposed to the standard atmosphere (*see* Annex A), condition it until the mean difference between the marks in each pair of temporary marks is less than 0.25 percent of the final average length.

6.2.3 *Final Measurements*

Remove the temporary marks, place the fabric on the table and, manipulating it as described in **6.2.1** make marks at 3 m or 2 m intervals, as relevant as prescribed in **6.1**, and measure the length of the portion between the last mark and the end of the pieces.

6.2.4 Determine each of the two lengths measured in accordance with **6.2.3** by counting the number of 3 m or 2 m units, as relevant, marked on the piece and adding the length of the remaining portion. Take the mean of the two results to the nearest centimetre as the length of the piece.

6.3 Method 2

6.3.1 *Relaxation and Relaxed Length*

Allow the piece to relax, free from applied tension, in the prevailing atmosphere for at least 24 h. Then place the piece on the table (at full width, or folded down the middle if received in this state) and use the procedure given in **6.2.3** to measure its relaxed length.

6.3.2 *Marking for Determination of Correction Factor*

Manipulate the piece as described **6.2.1** until the middle 3 to 4 m portion lies flat and free from applied tension on the table, and on this portion make four pairs of datum marks, the distance between the marks in each pair being equally spaced across the width of the fabric but no pair being nearer to a selvedge than one-tenth of the width of the fabric. Measure and record the distance between the marks in each pair.

6.3.3 *Conditioning and Final Measurements*

Freely expose the portion marked as in **6.3.2** (with or without removal from the piece) to the standard atmosphere until the mean difference between successive measurements, made at intervals of at least 24 h, of the distance between the marks in each pair of datum marks is less than 0.25 percent.

6.3.4 Calculate the length of the piece (to the nearest centimetre) by the formula:

$$L_c = \frac{L_r \times L_{sc}}{L_s}$$

where

L_c = length in cm of the piece after conditioning;

L_r = length in cm of the piece after relaxation in the prevailing atmosphere (calculated as in **6.2.4** from the results of measurements made in **6.3.1**);

L_{sc} = mean distance in cm between the datum marks on the conditioned portion; and

L_s = mean distance in cm between the datum marks on the relaxed portion before conditioning (*see* **6.3.2**).

6.4 *Calculation of Deficiency of Length in a Lot*

6.4.1 For calculating the deficiency of length in a lot, note down the following:

a) length of fabric, as declared by the manufacturer in the despatch note or challan (D);

b) total of lengths marked on all the bales in the lot (C);

c) total of lengths marked on all the bales selected in the sample (B);

d) total of lengths marked on all the pieces in the sample (A);

e) total of lengths marked on all the pieces in the test sample (M); and

f) total of measured lengths of all the pieces in the test sample (T).

6.4.2 *Calculate and report as follows:*

Case 1 — If $T \geq M$ and $A \geq B$ report that there is not length deficiency in the lot.

Case 2 — If $T \geq M$ but $A < B$, report length deficiency of lot as 'X' metres where

$$X = D - C \times \frac{A}{B}$$

Case 3 -- If $T < M$ but $A \geq B$, report length deficiency of lot as 'X' metres where

$$X = D - C \times \frac{T}{M}$$

Case 4 – If $T < M$ and $A < B$, report length deficiency of lot as 'X' where X is either equal to $D - C \times \frac{T}{M}$ or equal to $D - C \times \frac{A}{B}$ whichever is greater.

7 DETERMINATION OF WIDTH

7.1 Measurements

7.1.1 Take each measurement to the nearest millimetre and with the steel rule resting on the fabric in a direction at right angles to the selvedge.

7.1.2 Fabric folded down the middle, if received in that state, may be relaxed and conditioned in that state, but all measurements shall be taken from edge to edge with the fabric open and laid flat.

7.2 Method 1 For Pieces of Length Greater than 5 m

7.2.1 *Preliminary marking*

Place the piece on the table (at full width, or folded down the middle if received in this state) so that the first 1 to 2 m portion lies flat and free from applied tension, and make a temporary mark (used only to determine completion of relaxation and conditioning), at a point close to a selvedge and approximately 1 m from the end of the piece. Then draw the fabric gently along the table until the middle portion of the piece lies flat and free from applied tension, and make a second mark. Finally, draw the remainder of the fabric gently along the table until the last 1 to 2 m portion lies flat and free from applied tension and make a third temporary mark.

7.2.2 *Conditioning*

With the fabric so arranged as to be free from applied tension and freely exposed to the standard atmosphere (*see* Annex A), condition it until the difference between successive measurements, made at intervals of at least 24 h, of the appropriate width of the fabric as determined at the three marked measuring points is less than 0.25 percent at each measuring point.

7.2.3 *Final Measurements*

Remove the temporary marks place, the fabric on the table and, manipulating as described in **7.2.1** measure the width of the fabric at least five times at equal intervals of not more than 10 m along the length of the piece, the first measurement being made at a position at least 1 m from one end of the piece and the last measurement at least 1 m from the other end.

7.3 Method 1 — For Pieces (Samples) of Length at least 0.5 m and not Exceeding 5m

With fabric laid flat on the table and free from applied tension, made at least four marks at equal intervals at points close to a selvedge, the first and the last marks being made not closer to the adjacent end of the fabric than one fifth of the length of the sample. Then expose the sample to the standard atmosphere and condition it as described in **7.2.2** but taking measurements at each mark. Record the final readings at each point.

7.4 Take the mean of the final measurement made in accordance with **7.2.3** or **7.3** (as relevant) as the width of the piece.

7.5 Record the Minimum and Maximum Widths

7.6 Method 2

7.6.1 *Relaxation and Relaxed Width*

Allow the piece to relax, free from applied tension, in the prevailing atmosphere for at least 24 hours. Then place the piece on the table (at full width) or folded down the middle if received in this state and use procedure given in **7.2.3** to determine its relaxed width.

7.6.2 *Marking for Determination of Correction Factor*

Manipulate the piece as described in **7.6.1** until the middle 2 to 3 m portion lies flat and free from applied tension on the table, and on this portion make four marks at points close to a selvedge and at least 25 cm but preferable 50 cm apart. Measure and record the width at each of the four marks.

7.6.3 *Conditioning and Final Measurements*

Freely expose the portion marked in accordance with **7.6.2** (with or without removal from the piece) to the standard atmosphere until the difference between successive measurements, made at intervals of at least 24 hours, of the width of the fabric is less than 0.25 percent at each of the four measuring points. Record the mean of the last four readings.

7.6.4 Calculate the width of the piece by the formula:

$$W_c = W_r \times \frac{W'_c}{W_s}$$

where

W_c = width in cm of the piece after conditioning:
W_r = mean width in cm of the piece after relaxation (*see* **7.6.1**);

W_{sc} – mean width in cm of the marked portion after conditioning (*see* **7.6.3**); and

W_s – mean in cm of the marked portion after relaxation and before conditioning (*see* **7.6.2**).

7.6.5 Calculate the minimum and the maximum width of the test piece by the formula:

$$W_m = W_{mr} \times \frac{W_{sc}}{W_s}$$

where:

W_m – minimum (or maximum, as relevant) width in cm of the piece after conditioning;

W_{mr} – minimum (or maximum, as relevant) width in cm of the piece after relaxation (*see* **7.6.1**);

W_{sc} – mean width in cm of the marked portion after conditioning (*see* **7.6.3**); and

W_s – mean in cm of the marked portion after relaxation and before conditioning (*see* **7.6.2**).

7.7 Rounding Off

7.6.1 Round off the widths calculated in accordance with **7.4** and **7.6.4** as follows:

a) Widths over 10 cm and not exceeding 50 cm to the nearest millimetre.

b) Widths over 50 cm and not exceeding 100 cm to the nearest 5 mm.

c) Widths over 100 cm to the nearest centimetre.

7.7.2 Round off the minimum and maximum width recorded in accordance with **7.5** and calculated in accordance with to the nearest millimetre.

8 TEST REPORT

The test report shall include the following particulars:

a) Type of the material tested;

b) Length of fabric;

c) Deficiency in length (if requireed in case of lot of fabric);

d) Width of the piece: average, minimum and maximum width;

e) Whether the results were obtained by Method 1 or Method 2;

f) Whether or not the results include the lists or selvedges;

g) Details of any deviation from the specified test procedure.

ANNEX A

(*Clauses* 6.2.2 *and* 7.2.2)

ARRANGEMENT OF PIECES FOR CONDITIONING AND MEASUREMENT

A-1 A convenient and effective method of arranging a long piece of fabric for conditioning so that it is free from applied tension and is well exposed to the conditioning atmosphere is to unroll the piece and lay it in loose corrugated folds of suitable size (*see* Fig. 1).

A-2 During marking and measuring, it is essential that the piece of fabric whose width is being determined should be free from tension as it lies on the measuring table. To achieve this, it has been found convenient to cuttle-fold (*see* Fig. 2) the ends of the piece which extend beyond the portion being measured, thus producing a stack of fabric at each end of the portion being measured.

A-3 If the measuring table is too short to enable this method to be used, suplementary tables may be used at each end of the measuring surface provided that such extra tables are of exactly the same height and width as those of the main table, and that they are so placed as to form (with the measuring table) a continuous rectangular surface.

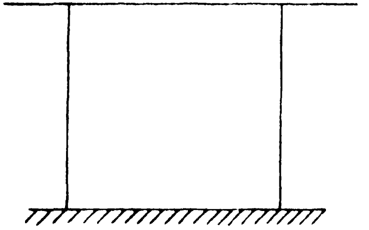


FIG. 1 LOOSE FOLDING

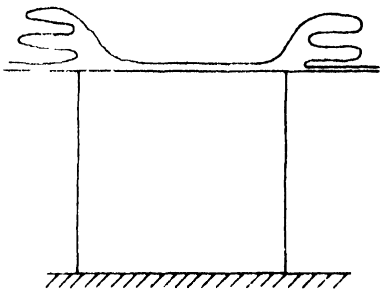


FIG. 2 CUTTLE FOLDING

DETERMINATION OF THREADS PER UNIT LENGTH IN WOVEN FABRICS

(*Source* : **IS 1963 : 1981**)

Jute industry is an export oriented industry and the overseas consumers use the terms 'porter' and 'shots' for expressing warp and weft threads per unit length of jute fabrics. For the convenience of the overseas consumers conversion factors for converting values of warp threads per decimeter to 'porter' and weft threads per decimetre to 'shots per inch' have been given in the standard (*see* Note under **5.3**).

Apart from the two methods given in this standard, method based on use of different types of line gratings is also followed.

1 SCOPE

1.1 It prescribes two methods for determination of warp threads and weft threads per unit length (per centimetre and per decimetre) in woven fabrics.

1.2 The methods are applicable to all textile fabrics irrespective of their composition (that is, whether they are made of cotton, wool, silk, jute, man-made fibres or blends of two or more such fibres), manufacturing processes and finishing treatments.

2 TERMINOLOGY

For the purpose of this test method the following terms shall apply.

2.1 Porter

The value obtained by counting in jute fabric the number of warp threads per gauge length of 47 mm (or 37/20 inch) and dividing it by the number of threads per split (2 for hessian, 3 for single warp twill cloth, 4 for double warp plain fabric and 6 for double warp twill cloth).

NOTE — This definition of 'porter' based on the Indian practice refers to the finished fabric, and has to be distinguished from the Dundee practice according to which 'porter' is evaluated in terms of loom reed used in weaving the cloth

2.2 Shot

Single thread of weft yarn in jute fabrics running from selvedge to selvedge. It is inserted in one passage of the shuttle across the loom.

3 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

3.1 Prior to test, the fabric shall be conditioned to moisture equilibrium from dry side, in the standard atmosphere of 65 ± 2 percent relative humidity and 27 + 2°C temperature as prescribed in IS 6359:1971 (*see* Section B-1/1).

3.2 The test shall be carried out in a standard atmosphere (*see* **3.1**).

3.3 The conditioning and testing may also be carried out in prevailing atmosphere, if agreed between the parties.

4 GENERAL INFORMATION

4.1 Choice of Method

Method A (*see* **5**) — This method is suitable for fabrics, the individual threads of which can be easily identified with a thread counting glass.

Method B (*see* **6**) — This method is suitable for fabrics, the individual threads of which cannot be easily identified with a thread counting glass.

NOTE — It may be noted that none of these methods may be applicable to certain special type of fabrics, such as Moleskin, Lappet, Butta, Leno Weaves, etc

4.2 Determination shall not be made (a) within 50 mm from the selvedges, or (b) within two metres from either end of a piece, roll or bolt. In case of fabrics having width from 10 cm to 20 cm the selvedge ends shall be excluded while counting.

NOTE — This is not applicable to narrow fabrics

4.3 Narrow Fabrics

In case of narrow fabrics having width of 10 cm or less, all warp threads including selvedge ends shall be counted and expressed as threads per full width.

4.4 Design Fabrics

For design fabrics, it is convenient (a) to determine the number of units in a weave repeat from a point paper diagram, and (b) to count (i) the number of whole repeats, and (ii) remaining units, in the distance across which the threads are to be counted; and calculate from the data so obtained, the number of threads per centimetre or decimetre, warpway of weftway as required.

4.5 For the purpose of determining the distance across which the number of threads is to be counted, assume the fabric to have the number of warp and weft thread per centimetre or decimetre as in the material specification, as specified in an agreement between the buyer and the seller, or by actual determination of thread count in one or two places.

5 METHOD A – BY TRAVERSING THREAD COUNTER

5.1 Apparatus

A thread counter, equipped with a low power microscope of suitable magnification and a pointer which traverses along a graduated base, shall be used. However, in the absence of such a thread counter, an ordinary counting glass with an aperture satisfying the requirements of **5.2** may be used.

NOTE — It is recommended that a table with a ground glass top illuminated from below should be used. Such a table greatly facilitates the work involved.

5.2 Warp and Weft Threads per Centimetre or Decimetre

5.2.1 Lay on a flat table a portion of one of the pieces constituting the test sample and smoothen it out. Place the counting glass with the pointer at zero on the piece in such a way that (a) on turning the screw the pointer moves in a direction parallel or perpendicular to warp threads, depending upon which set of threads (warp or weft) is being counted, and (b) the pointer shall coincide either with the right hand or the left-hand edge of a thread, depending on whether the counting is started from right to left or from left to right direction. Find the number of warp or weft threads by counting the number of units (normally comprising one thread and one space) and including as a fraction, any part of such unit in a distance L (*see* **4.5**), which shall be:

a) 50 mm, if the number of threads are 20 per centimetre (200 per decimetre) or less;

b) 20 mm, if the number of threads are more than 20 per centimetre (200 per decimetre), but less than or equal to 100 per centimetre (1 000 per decimetre); and

c) 10 mm, if the number of threads are more than 100 per centimetre (1 000 per decimetre).

NOTE — Counting edge of the thread counter should be placed always either parallel to the warp threads or perpendicular to the warp threads as the case may be

5.2.2 Following the procedure prescribed in **5.2.1** determine the number of warp and weft threads per centimetre or decimetre as required, in at least four more places evenly distributed along the width and length of the piece. Avoid counting same set of warp or weft threads more than once. Average all the observed values and note the value so obtained as the number of warp and weft threads per centimetre or decimetre in the piece as the case may be.

NOTE — In case of weft threads, it is preferable to have at least 10 readings, if the size of the sample permits

5.2.3 Calculate the number of warp and weft threads per centimetre or decimetre as the case may be by the following formula:

$$n = \frac{N}{L} \times 10 \text{ (or } 100)^{*}$$

where

n = number of threads per cm (or dm)*;

N = observed number of threads in the distance L; and

L = distance, expressed in mm, across which the threads are counted; 50 or 20 or 10 mm, as the case may be.

5.3 Determine in a similar manner (*see* **5.2**) warp threads and weft threads per centimetre or decimetre as required of the remaining pieces in the sample and find the mean of the value for warp threads per centimetres or decimetre as required and the mean of the value for weft threads per centimetre or decimetre, respectively.

NOTE — For converting 'warp threads per cm or dm' to 'porter' and 'weft threads per cm or dm' to 'shots per inch' in case of jute fabrics, the following conversion factors may be used.

a) Porter.		Multiply	
		Threads/cm by	Threads/dm by
i) For hessian (Plain weave) cloth	=	2 349	0 234 9
ii) For double warp plain weave cloth	=	1 175	0.117 5

---

*Value in parenthesis is used for number of threads per dm.

iii) For single warp 2/1 twill cloth	=	1.566	0.156 6
iv) For double warp 2/1 twill cloth	=	0.783	0.078 3
b) Shots/inch	=	2.54	0.254 0

6 METHOD B – BY DISSECTION OF FABRIC

6.1 Apparatus

6.1.1 *Clamps*

Use any of the following clamps (*see* also Table 1):

a) Type 'A' Clamp – A clamp with two parallel pins with their points 50 mm apart,
b) Type 'B' Clamp – a clamp with two parallel pins with their points 20 mm apart, and
c) Type 'C' Clamp – A clamp with two parallel pins with their points 10 mm apart.

NOTE — An outline of the clamp is shown in Fig. 1.

6.1.2 *Forceps*

One pair of pointed forceps for removing threads.

6.2 Warp and Weft Threads per Centimetre or Decimetre

6.2.1 Take one of the pieces constituting the sample and cut out from it a specimen of the width and length as specified in Table 1. The length of the specimen shall be along the weft threads for detaining number of warp threads per centimetre or decimetre and along the warp threads for determining number of weft threads per centimetre or decimetre. Lay the specimen on table with the length running from left to right.

Take an appropriate type of clamp (*see* Table 1) and position it centrally over the specimen. Then pass the pins on the clamp through the specimen. Remove using forceps, the threads remaining outside of cloth pins, leaving only the gauge length of specimen between them, and such threads through which the pins pass. From this gauge length of the specimen remove the threads one by one and count the number of threads within the gauge length.

6.2.2 Following the procedure prescribed in **6.2.1**, determine the number of warp and weft threads per centimetre or decimetre as required, in at least four more places equally distributed along the width and length respectively of the piece. Average all the observed values and note the value so obtained as the number of warp and weft threads per centimetre or decimetre in the pieces as the case may be.

NOTE — In case of weft threads, it is preferable to have at least 10 readings, if the size of the sample permits.

6.2.3 Calculate the number of warp and weft threads per centimetre or decimetre by the following formula:

$$n = \frac{N}{L} \times 10 \text{ (or 100)*}$$

where

n = the number of threads per cm (or dm)*;
N = observed number of threads in the gauge length L; and
L = gauge length, that is, the distance expressed in mm, between the pins on the clamp; 50 or 20 or 10 mm, as the case may be.

6.3 Determine in a similar manner (*see* **6.2**) warp threads and weft threads per centimetre or decimetre as required of the remaining pieces in the sample and find the mean of the values for warp threads per centimetre or decimetre and the mean of the values for weft threads per centimetre or decimetre respectively (*see also* Note under **5.3**).

Table 1 Number of Threads, Length of Specimen, Width of Specimen, Gauge Length and Type of Clamp

(*Clauses* 6.1 *and* 6.2.1)

All dimensions in millimetres.

No. of Threads (*see* 4.5) (1)	Length of Specimen (2)	Width of Specimen (3)	Gauge Length (4)	Type of Clamp (5)
20 per cm (200 per dm) or less	80	15	50	A
More than 20 but less than or equal to 100 per cm (or more than 200 but less than or equal to 1 000 per dm)	50	15	20	B
More than 100 per cm (or more than 1 000 per dm	40	15	10	C

---

*Value in parenthesis is used for number of threads per dm.

7 REPORT

The report shall include the following information:

a) Description of the material tested,

b) Method used;

c) Atmospheric conditions:

    1) Standard atmosphere, or

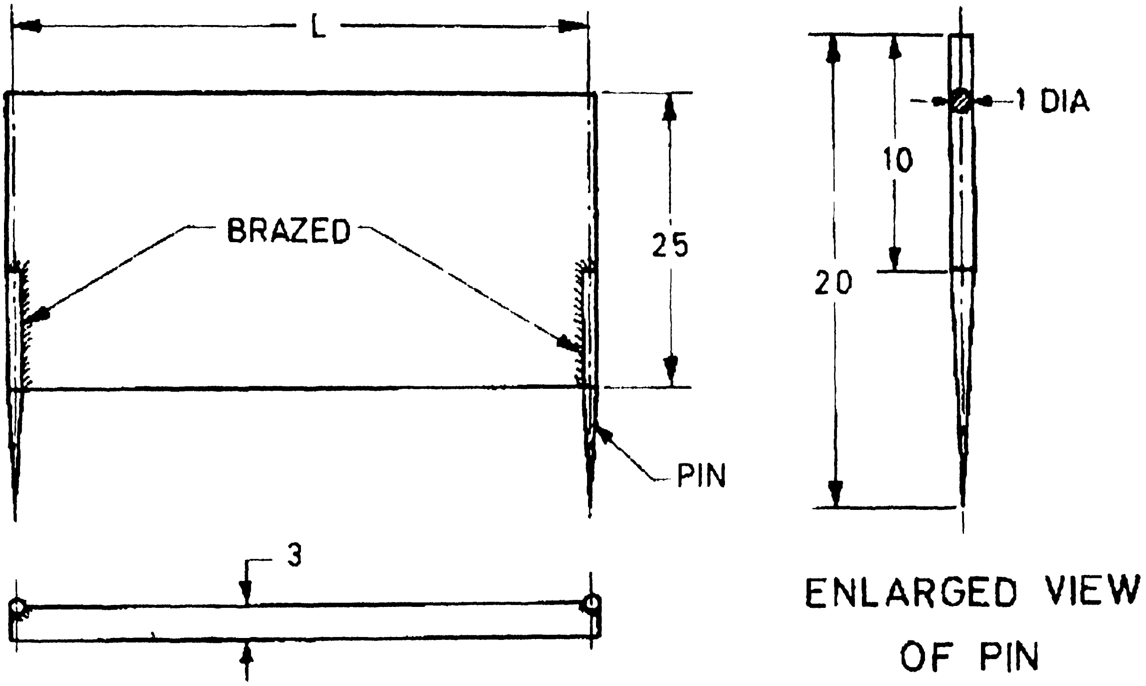
    2) Prevailing atmosphere (give relative humidity and temperature); and

d) Results

    1) Number of warp threads per cm or dm, and

    2) Number of weft threads per cm or dm.

NOTE The value should be rounded off to first decimal place in the case when the results are reported for threads per centimetre



L Gauge length 50 mm (Type A Clamp)

or

20 mm (Type B Clamp)

or

10 mm (Type C Clamp)

All dimensions in millimetres

FIG. 1 CLAMP

METHODS FOR DETERMINATION OF WEIGHT PER SQUARE METRE AND WEIGHT PER LINEAR METRE OF FABRICS

(*Source* : **IS 1964 : 1970**)

1 SCOPE

1.1 It prescribes three methods for determination of weight per square metre and weight per linear metre of fabrics.

1.2 Excepting for jute fabrics and tyre cord fabrics, the methods prescribed in this standard are applicable to all textile fabrics irrespective of their composition (that is, whether they are made of cotton, wool silk or man-made fibres or blends of two or more such fibres), manufacturing processes and finishing treatments.

1.2.1 The methods are also applicable to narrow fabrics (*see* **3.2**).

2 PRINCIPLES

In Method A, the material is conditioned to moisture equilibrium in standard atmospheric conditions and then the weight is determined; in Method B, oven-dry weight of the material is determined and then to this is added the commercial moisture regain value of the material; and in Method B, the moisture present in the material is determined and then the weight of the fabric is corrected to the commercial moisture regain value.

3 GENERAL INFORMATION

3.1 Choice of Method

Any of the Methods A, B or C may be used for the determination of weight per square metre and weight per linear metre of fabrics depending upon the type of the instruments and facilities available.

NOTE — Method C is a quick and convenient method for the determination of weight per square metre and weight per linear metre of fabrics particularly intended in bulk testing/inspection, but in case greater accuracy is required Method A or B shall be followed

3.2 Narrow Fabrics

In case of narrow fabrics the weight per unit length shall preferably be determined from the weights and lengths of complete rolls, but if this is not possible a minimum length of 5 metres shall be used.

4 METHOD A — CONDITIONED WEIGHT METHOD

4.1 Apparatus

4.1.1 *Horizontal, Flat, Smooth Table*

4.1.2 *Graduated Steel Scale*

4.1.3 *Balance* – capable of weighing to an accuracy of 0.5 g.

4.2 Atmospheric Conditions for Conditioning and Testing

4.2.1 Prior to test, the test samples shall be conditioned to moisture equilibrium from dry side in the standard atmosphere of 65 ± 2 percent relative humidity and 27 ± 2°C temperature.

NOTE — The time required for a fabric to reach moisture equilibrium depends mainly on

a) the thickness of the fabric or weight per unit area,
b) the closeness of the weave,
c) the hygroscopicity of the textile material comprising the fabric, and
d) type of finish given to the fabric

When the test samples have been exposed to standard atmosphere for at least as much time as given below in such a way as to expose as far as possible, all portions of the specimen to the atmosphere they shall be deemed to have been conditioned satisfactorily for the purpose of this test:

Textile Fabrics having Equilibrium Moisture Regain Values at Standard Atmosphere Percent	*Time* hours
Less than 4	6
From 4 to 10	12
Above 10	24 to 48

4.2.2 The test shall be carried out in a standard atmosphere (*see* **4.2.1**).

4.3 Procedure

Take the conditioned test sample (*see* Note) and determine its weight to an accuracy of 0.5g.

NOTE — If the facilities to condition the full cut or roll of fabric are not available, cut swatches of 250 ± 2 mm × full width of fabric including selvedges, and condition them. The swatches shall be so cut as to be representative of the lot.

4.3.1 Determine the length and width of sampled according to IS 1954:1969 'Method for determination of length and width of fabrics (*first revision*)' (*see* Section B-3/1).

4.4 Calculations

Calculate the weight per square metre and weight per linear metre by the following formula:

a) In case of full length pieces:
   1) Weight, in grams, per square metre (g/m²) $= \frac{W}{A \times B} \times 10^5$
   2) Weight, in grams, per linear metre (g/m) $= \frac{W}{A} \times 10^3$
b) In case of swatches of 250 mm × full width.
   1) Weight, in grams, per square metre (g/m²) $= \frac{W \times 4 \times 10^5}{B}$
   2) Weight, in grams, per linear metre (g/m) $= W \times 4 \times 10^3$

NOTE — Conversion equation:

$$\text{Weight in g/m} = \text{Weight in g/m}^2 \times \frac{B}{100}$$

where

W - weight of specimen in Kg.
l length of fabric in m. and
B - width of fabric in cm.

4.5 Similarly, determine the weight per square metre and weight per linear metre of at least four more test specimens and determine the average of all the values.

5 METHOD B – OVEN-DRY WEIGHT METHOD

5.1 Apparatus

5.1.1 *Horizontal, Smooth, Flat Table*

5.1.2 *Graduated Steel Scale*

5.1.3 *Drying Oven*

Suitable for drying sample to constant weight at 105 to 110°C.

5.1.4 *Balance*

Capable of weighing to an accuracy of 0.5g.

5.2 Procedure

5.2.1 Lay the sample or one end of the cut or roll smoothly on a flat table. Mark either full width or square swatches (at least 5) with the help of the scale and T-square of the dimension given below:

a) 250 ± 2 mm × full width of cloth including selvedges, and
b) 250 ± 2 mm square.

Cut the swatches so marked with the help of sharp scisors or razor blade. The swatches shall be so chosen as to be representative of the lot.

5.2.2 Determine the width of the fabric according to IS 1954:1969 (*see* Section B-3/1).

5.2.3 Dry the test specimen to constant weight in an oven maintained at 105 to 110°C and weigh to an accuracy of 0.5 g without removing the specimen from the oven, the draught being stopped during weighing.

5.3 Calculation

Calculate the weight per square metre or weight per linear metre of specimen, at the applicable commercial moisture regain value (*see* Note) by using the following formula:

a) In the case of full width swatches:
   1) Weight, in grams, per square metre (g/m²) $= \frac{4 \times W(100 + R)}{B}$
   2) Weight, in grams, per linear metre (g/m) $= \frac{W(100 + R)}{25}$
b) In case of square swatches:
   1) Weight, in grams, per square metre (g/m²) $= \frac{W(100 + R) \times 10^2}{625}$
   2) Weight, in grams, per linear metre (g/m) $= \frac{W \times B(100 + R)}{625}$

NOTE — Conversion equation

$$\text{Weight in g/m} = \text{Weight in g/m}^2 \times \frac{B}{100}$$

where

W — oven-dry weight of the specimen in g,
B — width of the fabric in cm, and
R - applicable commercial moisture regain, percent.

NOTE — Commercial moisture regain values of fabrics should be as stipulated in the relevant Indian Standard specifications for the material or in the absence of such specifications as agreed to between the buyer and the seller

5.4 Similarly, determine the weight per square metre and weight per linear metre of at least four more test specimens and calculate the average of all the values obtained.

6 METHOD C — MOISTURE REGAIN VALUE METHOD

6.1 Apparatus

6.1.1 *Moisture Meter*

6.1.2 *Balance*

Capable of weighing to an accuracy of 100 g.

6.2 Procedure

6.2.1 Determine the moisture regain of cloth in the cut or roll by the use of a suitable moisture meter. Take at least four readings on the roll at random, along the length covering different portions across the width.

6.2.2 Weigh the cut or roll to the nearest 100 g. Determine the weight of the packing material (tare weight) of the roll to the nearest 100 g and calculate the net weight of the cloth.

6.2.3 Determine the length and width of the fabric (in the cut or roll) according to IS 1954:1969 (*see* section B-3/1).

6.3 Calculations

From the moisture regain, weight and dimensions of the sample as determined in **6.2.1** to **6.2.3** Calculate the weight in grams per square metre and weight per linear metre at the applicable commercial moisture regain using the following formulae:

a) Weight, in grams per square metre (g/m²) $= \dfrac{W}{A \times B} \times \dfrac{(100+R)}{(100+M)} \times 10^5$

b) Weight, in grams, per linear metre (g/m) $= \dfrac{W}{A} \times \dfrac{(100+R)}{(100+M)} \times 10^3$

NOTE — Conversion equation
$$\text{Weight in g/m} = \text{weight in g/m}^2 \times \frac{B}{100}$$

where

W = net weight of cloth in a cut or roll in kg,

A = length of cloth in a cut or roll in m,

B = fabric width in cm,

R = applicable commercial moisture regain percent, and

M = average moisture regain percent observed.

NOTE — Commercial moisture regain value of fabrics should be as stipulated in the relevant Indian Standard specifications for material or in the absence of such specifications as agreed to between the buyer and the seller

6.4 Similarly, calculate the weight per square metre and weight per linear metre of at least four more test specimens and calculate the average of all the values so obtained.

7 REPORT

Report shall include the following:

a) Type of fabric tested;

b) Method followed;

c) Number of tests performed;

d) Weight per square metre;

e) Weight per linear metre; and

f) Moisture regain value used (in case of Methods B and C).

DETERMINATION OF MASS OF JUTE FABRICS

(*Source* : **IS 2387 : 1969**)

1 SCOPE

It prescribes methods for determination of mass per linear metre and mass per square metre of jute fabrics.

2 ATMOSPHERIC CONDITIONS FOR TESTING

The test may be carried out in the prevailing atmospheric conditions of the test room.

3 APPARATUS

3.1 For the purpose of this standard, the following apparatus shall be used:

a) Horizontal, smooth and flat table;
b) Graduated steel scale;
c) T-square;
d) Balance capable of weighing to an accuracy of 0.05 g;
e) Conditioning oven suitable for drying samples to constant mass at 105 ± 3°C;
f) A suitable moisture meter; and
g) Balance capable of weighing to an accuracy of 100 g.

4 METHOD A — BASED ON OVEN-DRY WEIGHING OF CUT SAMPLE

4.1 Procedure

Based on full width of sample.

4.1.1 Lay one end of cloth from a cut or roll smoothly on a flat table. By using a steel scale and a T-square make a swatch 500 ± 2 mm in length perpendicular to selvedges across the full width of the fabric and cut out the swatch so marked. This shall constitute a test specimen.

4.1.1.1 Prepare at least five such test specimens from a sample lot.

4.1.1.2 For determination of mass per square metre, measure the width of the specimen according to IS 1954 : 1969 'Method for determination of length and width of fabrics' given in B-3/1.

4.1.2 Dry the test specimen to constant mass in an oven maintained at 105 ± 3°C and weigh it to an accuracy of 0.2 percent of its mass without removing the specimen from the oven, the draught (*see* Note 1) being stopped during weighing. Calculate the mass per linear metre or mass per square metre of the specimen at the applicable contract regain value (*see* Note 2) by using the following formula:

$$\text{Mass per linear metre, in g} = \frac{M_d(100+R)}{50}$$

$$\text{Mass per square metre, in g} = \frac{2M_d\,(100+R)}{w}$$

where

M_d oven-dry weight of the specimen in g,
R Applicable contract regain percent (*see* Note 2), and
w width of the specimen in cm.

NOTES

1 In order to avoid the risk of oil evaporation, the draught in the drying oven shall not be continued throughout the drying period but shall be in operation only intermittently

2 Contract regain value of the jute fabrics, should be as stipulated in the relevant Indian Standard specifications for the material

3 For determination of mass per linear yard or mass per square yard to suit the needs of overseas consumers use the following formula

a) Mass per linear yard, in ounces Mass per linear metre, in g × 0.032 2

b) Mass per square yard, in ounces – Mass per square metre, in g × 0.032 2

4.1.3 Similarly determine the mass per linear metre or square metre of the remaining test specimens prepared as in **5.1.1**.

4.1.4 Calculate the mean of all the values obtained as above and report it as the mass per linear metre or square metre of the jute fabric in the lot.

4.2 PROCEDURE

4.2.1 Lay one end of cloth from a cut or roll, smoothly on the flat table and mark at least one 500 ± 2 mm square specimen from a cut and three 500 ± 2 mm square specimens from a roll with the help of a template taking different sets of warp and weft threads as far as possible and cut out the specimens marked. Specimens should not be taken within 50 mm from a selvedge or 200 mm from an end of a cut or roll.

4.2.1.1 Prepare at least ten such specimens from a sample lot.

4.2.1.2 Measure the width of the fabric according to IS 1954·1969 Method for determination of length and width of fabrics' give in Section B-3/1.

4.2.2 Dry the test specimen to constant mass in an oven maintained at 105 ± 30°C and weigh it to an accuracy of 0.2 percent of its mass without removing the specimen from the oven, the draught (*see* Note 1 under **5.1.2**) being stopped during weighing. Calculate the mass per square metre or mass per linear metre at the applicable contract regain value (*see* Note 2 under **4.1.2**) by the following formulae:

$$\text{Mass per square metre, in g} = \frac{M_d\,(100+R)}{25}$$

$$\text{Mass per linear metre, in g} = \frac{M_d\,(100+R)\times w}{2\,500}$$

where

M_d = Oven-dry mass of the specimen in g,
R = Applicable contract regain percent (*see* Note 2 under **4.1.2**), and
w = Fabric width in cm.

NOTE — For determination of mass per linear yarn or mass per square yard in ounces *see* Note 3 under **4.1.2**.

4.2.3 Similarly determine the mass per square metre or mass per linear metre of the remaining test specimens prepared as in **4.2.1**.

4.2.4 Calculate the mean of all the values obtained as above and report it as the mass per square metre or mass per linear metre of jute fabric in the lot.

5 METHOD B — BASED ON WEIGHING FULL CUT OR ROLL AND CORRECTING IT TO CONTRACT REGAIN

5.1 Procedure

5.1.1 Determine the moisture regain of cloth in the cut or roll by the use of a suitable moisture meter. Take at least four readings on the cut and ten readings on the roll at random, along the length covering different portions across the width.

NOTE — IJIRA (Indian Jute Industries'Research Association, Calcutta) Moisture Metre may be used for the purpose. This meter works on the principle of measuring the electrical resistance which changes with moisture content in the material. The specimen (jute product) is placed under the electrode gun having two poles of a specially designed spring loaded electrode. The small amount of current passing through the material held across the electrode poles is amplified and recorded on the meter, calibrated against the actual moisture regain, based on oven dry method of the material may also be used. The instrument shall be operated according to the manufacturer's instructions.

5.1.2 Weigh the cut to the nearest 100 g and the roll at least to the nearest 500 g. Determine the mass of the packing material (tare mass) of the roll to the nearest 100 g and calculate the net mass of cloth in the roll by deducting the tare mass from the gross mass. Determine the length and width of the fabric (in the cut or roll) according to IS 1954:1969.

5.1.3 From the moisture regain, mass and dimensions as determined in **5.1.1** and **5.1.2**, calculate the mass in grams per linear metre or per square metre at the applicable contract regain (*see* Note 2 under **4.1.2**) using the following formulae:

a) $\text{Mass per linear metre, in g} = \dfrac{1\,000\,M}{l} \times \dfrac{100+R_c}{100+R_o}$

b) $\text{Mass per square metre, in g} = \dfrac{10^5\,M}{l \times w} \times \dfrac{100+R_c}{100+R_o}$

where

M = net weight of cloth in a cut or roll in kg,
l = length of cloth in a cut or roll in m,
R_c = applicable contract regain percent (*see* Note 2 under **5.1.2**),
R_o = average moisture regain percent observed, and
w = fabric width in cm.

NOTE — For determination of weight per linear yard or weight per square yard in ounces *see* Note 3 under **5.1.2**.

5.1.4 Similarly determine the mass per linear metre and mass per square metre of all the cuts or rolls under test and calculate their average and report the averages.

6 REPORT

Report shall include the following information:

a) Type of fabric;
b) Method used;
c) Moisture regain value used;
d) Mass per square metre; and
e) Mass per linear metre.

DETERMINATION OF THICKNESS OF WOVEN AND KNITTED FABRICS

(*Source* : IS 7702:1975)

1 SCOPE

1.1 It prescribes a method for determination of thickness of woven and knitted textile fabrics under a specific pressure.

1.2 This method is not applicable to textile floor coverings, non-woven textile fabrics, rubber-coated fabrics, pile and raised fabrics.

2 PRINCIPLE

The thickness of a specimen of a woven or knitted fabric is measured as the distance between the reference plate on which the specimen rests and a parallel circular presser-foot that exerts a specified pressure on the area under test.

3 SAMPLING

The sample shall be drawn so as to be representative of the lot. Samples drawn in accordance with the procedure laid down in the material specification or as agreed to between the buyer and the seller shall be taken as representative of the lot.

4 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

The conditioning and testing shall be carried out in standard atmosphere at 65 ± 2 percent relative humidity and 27 ± 2°C temperature (*see also* Section B-1/1).

Prior to evaluation, the test sample shall be conditioned to moisture equilibrium in the standard atmosphere (*see* Note).

NOTE — For guidance purposes, it may be noted that the minimum time required to reach moisture equilibrium for the various types of textile materials having moisture regain values of less than 5 percent is about 6 hours while the same for those having moisture regain values of more than 5 percent 24 hours.

5 APPARATUS

5.1 Thickness Tester

The instrument used for testing the thickness of fabrics shall be provided with the following arrangements:

a) *Interchangeable Presser-Foot* — of area appropriate to the type of fabric to be tested (*see* Annex A).
b) *Reference Plate* — with a plane upper surface or diameter at least 50 mm greater than that of the presser-foot
c) *Means for Moving the Presser-Foot* — (in a direction normal to the upper surface or the reference plate) with its bearing surface maintained parallel [to obtain 1 in 500 (slope)] to the upper surface of the reference plate. The relevant specific pressure (*see* Annex A) can be applied to a test specimen supported on the plate.
d) *Gauge* — for registering the vertical distance between the bearing surfaces of the presser-foot and the reference plate to an accuracy of 1 percent for fabrics over 0.1 mm in thickness, and to 0.001 mm for fabric thickness not exceeding 0.1 mm.

6 PROCEDURE

6.1 Clean the presser-foot and the reference plate. Check that the presser-foot shaft moves freely. With the presser-foot so loaded as to exert the appropriate specified pressure on the reference plate, set the thickness gauge to read zero.

NOTE — The area of the presser-foot and the applied pressure shall be agreed between the buyer and the seller (*see* Annex A)

6.2 Raise the presser-foot and position the sample, without tension, on the reference plate so that no part of the area to be measured lies nearer to a selvedge than 150 mm. Ensure that the area chosen for the test is free from creases. Do not attempt to flatten out any creases, this is likely to affect the result.

6.3 Lower the presser-foot gently on to the sample and note the gauge reading after 30 seconds.

6.4 Similarly determine the thickness at 10 places on the sample so chosen that each such place contains different warp and weft threads, or courses and wales, as relevant.

7 CALCULATION

Calculate the arithmetic mean of the measurements taken in **6.3** and **6.4** to the degree of precision specified in **5.1** (d).

8 REPORT

The report shall include the following information:

a) The description of the fabric;

b) The area of the presser-foot used;

c) The applied pressure; and

d) The maximum, minimum and mean thickness of the test sample.

ANNEX A

(*Clauses* 5.1 *and* 6.1)

GUIDE TO THE SELECTION OF AREA OF PRESSER-FOOT AND APPLIED PRESSURE

A-1 PRESSER-FOOT

A-1.1 It is recommended that:

a) the ratio of foot diameter to fabric thickness be not less than 5:1, and

b) the area of foot may lie between 500 and 10 000 mm^2.

NOTE — The preferred sizes of the presser-foot are given below

Area mm^2	*Diameter* mm
500	25.22
1 000	35.68
2 500	56.43
5 000	79.78
10 000	112.84

A-2 Applied Pressures

A-2.1 It is recommended that the applied pressure may be 1, 5 or 10 kPa [Kilopascal (kPa) is approximately equivalent to 10 gf/cm^2].

DETERMINATION OF BREAKING LOAD AND ELONGATION OF WOVEN TEXTILE FABRICS

(*Source* : IS 1969:1985)

1 SCOPE

1.1 It prescribes methods for determination of breaking load and elongation at break of woven fabrics (conditioned or wet) using grab, ravelled-strip and cut-strip methods on constant-rate-of-loading, constant-rate-of-extension and constant-rate-of-traverse machines.

1.1.1 The methods are applicable to all woven textile fabrics irrespective of their composition (that is, whether they are made of cotton, wool, silk, jute or man-made fibres or blends or two or more such fibres), manufacturing processes and finishing treatments. It is also applicable to laminated fabrics but not to fabrics coated with rubber or plastics.

2 PRINCIPLE

The specimen is gripped between two clamps of the tensile testing machine in such a manner that the same set of yarns is gripped by both the clamps and a continual increasing load is applied longitudinally to the specimen by moving one of the clamps until the specimen ruptures. Values of breaking load and elongation of the test specimen are read from the indications of the machine.

3 TERMINOLOGY

For the purpose of this test method, the following definitions shall apply.

3.1 Grab Test

A test in which only a part of the width of the specimen is centrally gripped in the clamps for testing.

3.1.1 *Modified Grab Test*

Grab test in which lateral slits are made in the specimen to sever all yarns bodering the portion, the strength of which is to be tested; thus reducing the effect of the threads which are not directly gripped by the jaws to a practical minimum.

3.2 Strip Test

A test in which the full width of the specimen is gripped in the clamps for testing.

3.2.1 *Ravelled-Strip Test*

Strip test in which the specified width of the specimen is obtained by ravelling away yarns at the edges.

3.2.2 *Cut-Strip Test*

Strip test in which the specified width of the specimen is obtained by cutting the fabric.

3.3 Nominal Gauge Length

The length of a specimen under specified pre-tension, measured from nip to nip of the jaws of the holding clamps in their starting position.

3.4 Time-to-Break

The interval, measured in suitable units, such as seconds, during which the specimen is under a (generally increasing) tension, that is, absorbing the energy supplied before the breaking load is reached.

NOTE — Time-to-break does not include the time required to remove slack from the specimen. On machines supplied with an autographic recorder the time to break is indicated by the time elapsing after the pen registers the initial force sustained by the specimen until the pen registers the maximum force.

4 SELECTION OF THE TEST

4.1 The type of test to be done in any specific case depends on what has been specified in the material specification or as has been agreed to between the parties.

4.2 Grap Test Method

This method is used when it is desired to determine the effective strength of the fabric in use, that is, the strength of the yarns in a specific width together with the strength contributed by the adjacent yarns. The method is particularly suitable for heavy fabrics as well as those with high cover factor and in cases where ravelling is difficult or when the ravelled-strip starts ravelling further under stress.

4.3 Modified Grab Test Method

This method is used especially for fabrics with very high strength or for fabrics constructions where application of stress on ravelled strip specimen produces further unravelling.

4.4 Ravelled-Strip Test Method

This method is generally used when it is desired to determine the breaking load required to rupture specific width of fabric. This information is useful for comparing the effective strength of yarns in woven fabric with the strength of yarn before weaving.

4.4.1 *Full Width*

Tapes, ribbons and other narrow fabrics of less than 50 mm width are tested full width by this method.

4.5 Cut Strip Test Method

This method is used in case of heavily sized, felted, laminated fabrics or fabrics in which ravelling is not easy.

5 SAMPLING

5.1 The quantity of fabrics purported to be of one definite composition, construction and quality delivered to one buyer against one despatch shall consitutute the lot.

5.2 Sample to test conformity of a lot to a specification as regards to breaking load and elongation at break shall be selected so as to be representative of the lot.

5.3 Sample drawn in compliance with the specification for the material or as agreed to between the buyer and the seller shall be held to be representative of the lot.

5.4 Test at least five warpway and five weftway test specimens. As far as possible, only one test specimen shall be drawn from a piece in the test sample. The pieces in the test sample may be drawn from as many bales (or cases) in the lot as possible.

NOTE — Results of tests performed on small samples should be considered as representative of that small sample but should not be taken as representative of the fabric piece or lot from which the small sample was taken

6 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

6.1 Prior to test, the specimens shall be conditioned to moisture equilibrium from dry side and tested in the standard atmosphere of 65 ± 2°C percent relative humidity and 27 ± 2°C temperature as laid down in IS 6359:1971 'Method for conditioning of textiles' (*see* section B-1/1).

6.2 The test shall be carried out in a standard atmosphere (*see* **6.1**).

6.3 Wet Test — (*See* 9).

7 TESTING APPARATUS

7.1 A tensile testing machine provided with the following arrangements shall be used for testing:

a) Two clamps with the following provisions to grip the specimens:
   i) Each clamp of the machine shall consist of two metallic jaws and each jaw face shall be in line both with respect to its mate in the same clamp and to the corresponding jaws of the other clamp.
   ii) Each clamp shall be provided with a mechanical device so constructed that through its means a specimen can be secured firmly between the jaws of the clamps so that it does not slip during the test. Also, the edge of the surface of each jaws shall be such that it would not cut or damage the specimen during testing.

NOTE — The faces of the jaws are generally, flat, engraved or corrugated To avoid the chances of slippage or damage to the specimen, packing materials like paper, felt, leather, plastic or rubber sheet may be used.

b) Means for adjusting the distance between the clamps such that the specimens can be tested at 75 mm gauge length for grab test and at 200 mm gauge length for strip test.

c) Means for driving by power one of the pair of clamps at a specified constant-rate-or-traverse, loading or extension as the case may be, so that the test specimen breaks in 20 ± 3 seconds (average-time-to-break).

NOTE — If the arrangement for breaking the specimen within 20 ±3 seconds is not there, the test shall be carried out at a constant-rate-or-traverse machine (which is very popular and widely used in India) at the rate of 300 ±15 mm/min. In the case of jute and laminated fabrics, the rate of traverse shall be 300 ±15 mm per minute for grab and modified grab methods of test and 450 ± 15 mm/min for ravelled-strip and cut strip methods of test.

d) A scale or dial or authographic recording chart graduated so as to give load in a newtons (kilograms) and elongation in millimetres.

Table 1 Sizes of Test Specimens and Jaw Faces

(*Clause* 8.1)

All dimensions in millimetres.

Sl No.	Type of Fabric	Type of Test	Size of Test Specimen Length (*Min*) × Width	Size of Jaw Faces (*See* Note 3)		Gauge Length
				Upper (or Front) Jaw Face A × B	Lower (or Rear) Jaw Face A × B	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	All fabrics except jute	a) Grab test	150 × 100	25 × 25	25 × 25	75
		b) Modified grab test	200 × 100 400 × 100 (for high strength fabrics)	30 × 50	50 × 50	75
		c) Ravelled-strip test[1] (*see* Notes 1, 2 and 4)	325 × 60 (for close weave) 325 × 70 (for open weave)	75 × 25	75 × 25	200
		d) Cut-strip test (*see* Notes 1, 2 and 4)	325 × 50	75 × 25	75 × 25	200
ii)	Jute fabrics	a) Grab test	180 × 120	25 × 25 to 50	Equal to or bigger than the front jaw (col 5)	75
		b) Modified grab test	200 × 100 400 × 100 (for fabrics of high strength)	30 × 50	50 × 50	75
		c) Ravelled-strip test[2] (*see* Notes 1, 2 and 4)	325 × 120 (close weave) 325 × 140 (open weave)	100 × 25	100 × 25	200
		d) Cut-strip test (*see* Notes 1, 2 and 4)	325 × 100	100 × 25	100 × 25	200
iii)	Narrow fabrics and tapes	Full width (*see* Notes 1, 2 and 4)	325 × Full width	*See Note* 4		200

NOTES

1 For determining breaking load of fabric having elongation at break greater than 75 percent, the gauge lengths may be reduced to 50 percent of the values given in col 7.

2 This method is likely to give variable results on fabrics having less than 20 threads across the width of the specimen. However, if, it is agreed to perform a test on strips with less than 20 threads across the width, the actual number of threads shall be stated in the report.

3 The side of the jaw at right angles to the direction of application of load has been taken as *A* and that parallel to the direction of application of load has been taken as *B*.

4 For all types of strip tests, narrow fabrics and types being tested full width, jaw-faces shall be wider than the specimen width by at least 10 mm.

[1] Width after ravelling - 50 mm.

[2] Width after ravelling - 100 mm.

7.1.1 The load range of the machine shall be such that all the observed values would lie between 20 and 80 percent of the full-scale load. The permissible error in the machine at any point in this range shall not exceed ±1 percent.

7.2 A pair of scissors or a sharp blade, measuring scale, stop watch, etc.

8 SIZES OF TEST SPECIMENS, JAW FACES AND METHODS OF MOUNTING THE SPECIMENS

8.1 Sizes of Test Specimens and Jaw Faces

The sizes of test specimens and jaws faces and different types are given in Table 1.

8.2 Methods of Mounting the Specimen

8.2.1 *Grab Test*

The test specimen shall be centrally clamped with the same set of yarns gripped in the two clamps so that the longitudinal axis of the specimen is at right angles to the edges of the clamps after pretensioning (*see* **8.3**). Same length of specimen should extend beyond the ends of each jaw.

Example

To ensure that the specimen is centrally clamped with the same yarns in the two clamps, draw a longitudinal line at about 37mm from one edge perfectly parallel to the lengthwise yarns. Position the specimen in the lengthwise direction in the clamps such that the line drawn on the specimen runs adjacent to the sides of upper and lower edges of the clamps which are nearest to this edge.

8.2.2 *Modified Grab Test*

The test specimen shall be centrally clamped with the same yarns gripped in the two clamps after cutting the slits at the middle portion severing all yarns except those comprising the central 25 mm. portion as shown in Fig. 1. The specimen should extend through the jaws and project at least 10 mm at each end. The test specimen having very high strength and requiring special mounting device shall be mounted in a manner given in Fig. 2.

Example

To ensure that the slits cut on the two sides leave the central portion of 25 mm width, draw two longitudinal lines at about 37 mm from each edge perfectly parallel to the lengthwise yarn leaving 25 mm width in the centre. Position the specimen in the lengthwise direction in the clamps such that one of the lines drawn on the specimen runs adjacent to the sides of upper and lower edges of the clamps which are nearest to that edge.

8.2.3 *Ravelled and Cut Strip Tests*

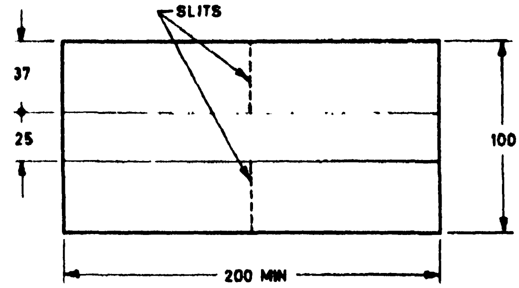
Mount the test specimen centrally in the clamps with the longitudinal threads parallel to the direction of application of load, after pre-tensioning (*see* **8.3**).

8.3 Pre-tensioning

8.3.1 Unless the use of a lower tension is necessary (*see* **8.3.2**) apply either of the following tensions:

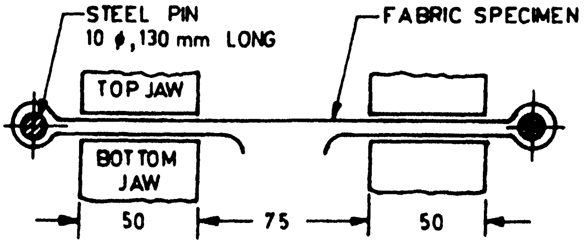
a) a tension equal to 1 ± 0.25 percent of probable breaking load, and

b) the tensioning given in Table 2 appropriate to the mass per unit area of the fabric under test.



All dimensions in millimetres.

FIG. 1 TEST SPECIMEN FOR MODIFIED GRAB TEST



All dimensions in millimetres.

FIG. 2 MOUNTING OF TEST SPECIMEN (HIGH STRENGTH FABRICS) — MODIFIED GRAB TEST METHOD

Table 2 Pre-Tensioning of Specimens

Mass, g/m^2	Force, N
Up to and including 150	2
Over 150 to and including 500	5
Over 500	10

8.3.2 If the tension chosen in terms of **8.3.1** elongates the specimen by more than 0.5 percent, use a lower tension that is acceptable to the parties interested in the test results.

NOTE — If owing to the construction of the testing machine or for other reasons, no pre-tension is applied, this shall be stated in the test report.

9 PREPARATION OF TEST SPECIMENS

9.1 From each piece in the sample selected as in **5**, cut (from a position taken at random but at least 3 m from an end of the piece) a test sample of length at least 1 m and of full width. Ensure that areas that are creased or that have visible faults are not included in the sample.

9.2 From the test samples two sets of test specimens of required size shall be cut, one set in the warp direction and the other in the weft direction. Each set shall consist of at least five specimens, except that if a higher degree of precision is required, more specimens shall be tested. The specimens shall be as representative of the test sample as possible. No two specimens shall contain the same longitudinal threads, and no warp direction specimen shall be cut from near either selvedge then one-tenth of the width of the test sample. As far as possible, only one test specimen shall be drawn from a piece in the test sample. Additional specimens shall be used for adjusting the time-to-break of testing machine.

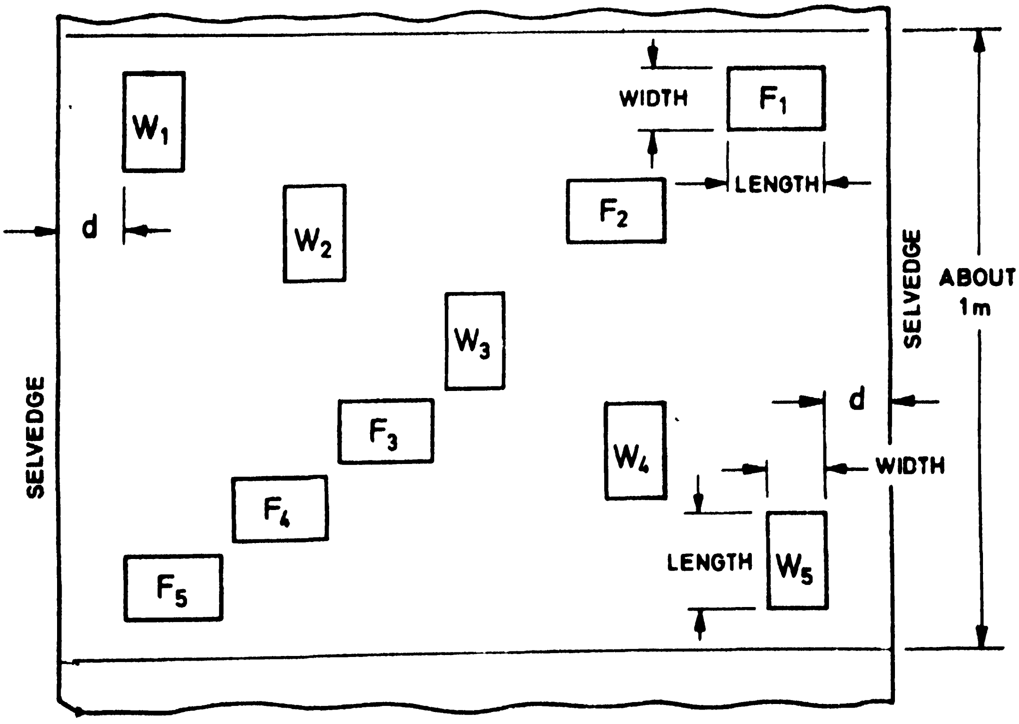
NOTE — In case the lot size is small, more than one test specimen may be drawn from a piece in the test sample.

9.3 The lengthwise direction shall be parallel to the warp or weft direction for which the breaking load is required. Specimens cut in each direction shall be distributed as far as possible so that no two warpway specimens contain the same set of warp yarn and no two weft way specimens contain the same set of weft yarns. One possible lay out of cutting five warpway and five weftway test specimens from one test sample is given in Fig. 3.

NOTE — The test specimens may be marked as shown in Fig. 3 to avoid mix-up of samples of warp and weft.

9.4 Wet Test Specimens

9.4.1 When the wet breaking load of the fabric is required in addition to the dry breaking load, specimens of same width and of at least twice as long as the specimens required for a dry test shall be cut. Each specimen then shall be cut crosswise in two parts, one for determining the dry breaking load and the other for



W = Warp test specimens and *F* = Weft test specimens. The distance *d* shall not be less than 100 mm.

FIG. 3 LAYOUT OF TEST SPECIMENS

determining the wet breaking load to ensure that each pair of specimens contains the same longitudinal yarns. For fabrics which shrink excessively when wet, the initial length of test specimens for the determination of wet breaking load must be greater than that of specimens for dry breaking load tests.

9.4.2 The specimens meant for testing wet strength shall be immersed in distilled water for at least 1 hour. If necessary, 0.5 g/l of nonionic neutral wetting agent may be added.

9.4.3 The test should be completed within two minutes after the removal of test specimens from distilled water or aqueous solution containing the wetting agent.

10 PROCEDURE

10.1 Set the clamps of the testing machine so that the distance between them is 75 mm for grab test and 200 mm for strip test. Use an additional specimen (**9.2**) and, after pre-tensioning (if relevant), set the moving clamp in motion at a rate estimated to result in an average time to break as specified (**7.1**). Note the breaking load and the time-to-break. Return the moving clamps to its zero position, remove the ends of the broken specimen, and repeat the above procedure on two additional specimens. If the average time-to-break of these three specimens does not fall within 20+3 seconds, discard the results and, using a suitable different rate of operation of the moving clamp, repeat the procedure described above. Continue in this way until the average time-to-break is 20 ± 3 s.

10.2 Set the clamps of the testing machine so that the distance between them is 75 mm for grab test and 200 mm for strip test. Take a test specimen, say W'_1, as prepared in **9** and insert it in the clamps of the testing machine so that its longer side is parallel to the direction of application of load with approximately the same length of the fabric extending beyond the jaws of at each end. Secure the test specimen between the jaws of upper clamps. Through the free end of the specimen, apply an appropriate tension as in **8.3** and secure it between the jaws of the other clamps.

10.3 Operate the machine and carry the test to rupture and record the breaking load and elongation of the specimen. In case a fabric breaks in two or more stags record only the maximum load.

NOTE — If the specimen slips in the jaws or breaks inside the jaws, the reading should be discarded. If the break takes place within 5 mm from the edge of either of the jaws and the value of the break is appreciably below, say 50 percent of the average value of all other breaks, it should be discarded. If some yarns in a specimen fail to break due to improper tensioning, the reading shall be discarded. In case of rejection another specimen is to be tested in lieu thereof.

10.4 Open both the clamps and remove the broken specimen. Take a fresh specimen and determine its breaking load and elongation as given in **10.2** and **10.3** and repeat the test with the remaining test specimens.

10.5 In a similar manner test weftway specimens.

11 CALCULATIONS

11.1 Calculate the mean breaking load separately for warpway and weftway test specimens as follows:

$$\bar{L} = \frac{\Sigma L_i}{n}$$

where

$\bar{L}$ = mean breaking load,
L_i = sum of the observed values of breaking load, and
n = number of observations.

11.2 Calculate the elongation at break separately for warpway and weftway test specimens and calculate the mean percentage elongation at as follows:

$$\bar{E} = \frac{\bar{E}_i \times 100}{n \times \text{Gauge Length}}$$

where

$\bar{E}$ = the mean elongation percent at break,
$\bar{E}_e$ = observed values of elongation at break, and
n = number of observations.

12 REPORT

The report shall include the following information:

a) Description of the material tested (width of tape if tested full width);
b) Condition of test (conditioned at standard atmosphere or wet, or both);
c) Type of test (grab, modified grab, ravelled-strip or cut-strip);
d) Gauge length;
e) Width of specimen;
f) Number of the threads in the strip (warp or weft if less than 20 threads); and
g) Dimensions of jaws.

DETERMINATION OF BURSTING STRENGTH AND BURSTING DISTENSION OF FABRICS: DIAPHRAGM METHOD

(*Source* : IS 1966:1975)

The test for tensile strength may be unsuitable for certain type of fabrics, such as knitted materials and lace, and for these textiles the measurement of bursting strength provides an alternative criterion of strength. The test may also be suitable for woven fabrics which are subjected to bursting pressures in use, for example, pump diaphragms and filter fabrics. In this test, the specimen breaks across the direction having the least breaking extension, but the bursting strength of the cloth cannot readily be calculated from its tensile strength in this direction since it is influenced by other aspects of the response of the fabric to biaxial stressing.

1 SCOPE

1.1 It prescribes a method for the determination of bursting strength and bursting distension of woven and knitted fabrics and felts.

1.1.1 This method is applicable to all textile fabrics, irrespective of their composition (that is, whether the fabric is made of cotton, wool, silk, jute or man-made fibres or a blend of two or more such fibres) and history (that is, the manufacturing processes involved and the finishing treatments).

2 TERMINOLOGY

For the purpose of this standard, the following definitions shall apply.

2.1 Bursting Strength

The maximum fluid pressure applied to a circular specimen in distending it to rupture. It is expressed in kilogram force per square centimetre (kgf/cm^2) or kilonewtons per square metre (kN/m^2).

NOTE — $1 kN/m^2 = \frac{kgf/cm^2}{102}$

2.2 Bursting Distension

The distension of a specimen at the bursting pressure. It is the maximum height in millimetres achieved at the time of bursting by the centre of the upper surface of the specimen during the test.

3 PRINCIPLE

A specified area of the sample of fabric under test is clamped over an elastic diaphragm by means of a flat annular clamping ring, and an increasing fluid pressure is applied to the underside of the diaphragm until the specimen bursts. The operating fluid may be either a liquid or a gas.

4 SAMPLING

4.1 Samples shall be selected so as to be representative of the lot.

4.2 Samples drawn in accordance with the procedure laid down in the material specification or as agreed to between the buyer and the seller shall be taken as representative of the lot.

5 TEST SPECIMENS

5.1 From the test sample, cut out at least 10 test specimens each 250 mm × 250 mm or 75 mm × 75 mm in size, by drawing one test specimen (*see* Note) from each of the pieces constituting the test sample; these shall constitute the test specimens.

NOTE — More than one test specimen may be cut out of one or more sample pieces to make up for 10 test specimens.

5.1.1 The system of clamping used generally permits tests to be applied without cutting out specimens (which may be resorted to, if desired). The sample of fabric available may sometimes be in one or more pieces but it should be possible to test it at 10 places. The 10 test areas shall be so distributed as to be representative of the sample and avoiding selvedges, creased or wrinkled places, and other such non-representative areas of the sample.

CAUTION : No portion of the material that has previously been gripped in the specimen clamp shall be used for a subsequent test.

6 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

6.1 The conditioning and testing shall be carried out in standard atmosphere at 65 ± 2 percent relative humidity and 27±2°C temperature (*see also* IS 6359:1971 'Method for conditioning of textiles' given in Section B-1/1).

6.2 Prior to evaluation, the test specimens shall be conditioned to moisture equilibrium in the standard atmosphere (*see* Note).

NOTE — For guidance purposes, it may be noted that the minimum time required to reach moisture equilibrium for the various types of textile materials having moisture regain less than 5 percent is about 6 hours while the same for those having moisture regain more than 5 percent is 24 hours

7 APPARATUS

7.1 For Test Diameter of 113 mm

7.1.1 The bursting strength tester shall have a flat base plate of diameter at least 140 mm, covered by a flat diaphragm of rubber or similar material (of thickness not more than 1 mm). A central hole in the base plate shall allow a controlled increase in fluid pressure to be applied to the underside of the diaphragm, so that the specimen bursts in 20 ± 3 seconds. The rate of flow of fluid through the hole in the base plate shall not vary more than ±20 percent throughout the test.

7.1.2 A clamping ring of internal diameter 113.00 ± 0.05 mm and of external diameter 140 mm (*Min*) shall be provided with a flat lower surface to hold the specimen firmly against the diaphragm at all points.

7.1.3 The lower face of the clamping ring may be lined with a thin layer of cork or other compressible material suitable for the fabric under test; if the face is unlined, its inner edge (or inner periphery) shall have a radius of 0.5mm.

7.1.4 Means shall be provided for applying the clamping ring with sufficient pressure to prevent the fabric specimen from slipping during the test. The specimen shall not be damaged by the action of the clamping ring.

7.1.5 Provision shall be made for indicating or recording the pressure under the diaphragm at any point in the range in which the machine is used to an accuracy of ± 1 percent. Means shall be provided for indicating or recording the bursting distension of the specimen to an accuracy of ± 0.25 mm.

7.2 For Test Diameter of 30.5 mm

7.2.1 All conditions shall be the same as in **7.1.1** to **7.1.5** except that the diameter of the base plate shall be at least 55 mm and the internal and external diameters of the clamping ring shall be 30.50 ± 0.05 mm and 55 mm (*Min*); respectively.

8 PROCEDURE

8.1 Place the test specimen or the area of the sample to be tested over the diaphragm so that it lies in a flat tensionless condition. Clamp it securely by means of the clamping ring. Increase the pressure smoothly so that the bursting strength of the fabric is reached in 20 ± 3 seconds.

8.1.1 Note the bursting strength and the bursting distension of the specimen. If the specimen bursts close to the edge of the clamping ring, record this fact and discard the reading, and carry out another test in lieu thereof.

8.1.2 Repeat the test with other test specimens or at other places on the test sample, as the case may be, to have at least 10 acceptable measurements.

8.2 Diaphragm Correction

With the same rate of fluid flow as employed in the above test, distend the diaphragm, without the presence of a specimen, but with the clamping ring in position, and note the pressure required to distend it by an amount equal to the average distension of the specimens. The pressure is the 'diaphragm correction'.

9 CALCULATION

9.1 Calculate the arithmetic mean of the measured values of bursting strength and from this subtract the diaphragm correction.

9.2 Express the arithmetic mean of the bursting distensions of the specimens selected for the calculation of bursting pressure to the nearest 2 percent.

10 TEST REPORT

The test report shall include the following information:

a) Mean bursting strength in kilogram force per square centimetre or kilonewtons per square metre;
b) Diaphragm correction;
c) Mean bursting distension; and
d) The type and capacity of the machine, the pressure range at which it was operated, and the test diameter of the specimen.

DETERMINATION OF TEAR RESISTANCE BY THE FALLING PENDULUM METHOD

(*Source* : IS 6489:1993/ISO9290:1990)

1 SCOPE

It specifies a method for determining the force required to propagate a tear, through a specified distance and from a specified slit, cut in a test specimen of textile fabric, under specified conditions of loading. The test method is suitable for all types of woven fabric (treated and untreated). The method is not applicable to nonwovens or knitted fabrics. Two procedures are given for preparing test specimens.

2 TERMINOLOGY

For the purpose of this test method the following definition shall apply.

2.1 Tear Resistance — The average force, in newtons, required to tear a test specimen over a specified length.

3 PRINCIPLE

A rectangular test specimen having a specified precut slit is subjected to a tearing force generated by the energy stored in pendulum-sector of specified dimensions. The energy expanded in tearing the specimen is used to determine the tear resistance of the specimen.

4 APPARATUS

4.1 Elements of the Apparatus

The apparatus essentially consists of a frame, mounted on rigid base, carrying a pendulum and pointer assembly. It shall also satisfy the details as given below with respect to various parts.

4.1.1 *Pendulum*, preferably formed by a sector of a circle, suitably mounted, free to swing about a horizontal axis from bearings of very low frictional resistance.

4.1.2 *Augmenting mass*, the apparatus shall have provision of augmenting masses that may be attached to the pendulum sector for further increasing the working capacity of the apparatus.

4.1.3 *Jaws*, a pair of jaws each 16 mm ± 0.5 mm deep and 37 mm ± 0.5 mm wide, one stationary jaw, fixed with respect to the base, and the other movable jaw, fixed with respect to the pendulum. When the pendulum is in the initial position, ready for the test, the jaws shall be separated by a distance of 2.8 mm ± 0.4 mm and so aligned that the test sample when clamped lied in a plane perpendicular to the plane of oscillation of the pendulum sector with the edges of the jaws gripping the test specimen in a horizontal line, a perpendicular to which through the axis of suspension of the pendulum sector is 104 mm ± 1 mm long. The angle made by this imaginary line and the vertical shall be 27.5 ± 5°.

4.1.4 *Pendulum-sector release mechanism*, for holding the pendulum-sector in a raised position, and for releasing it without imparting shock.

4.1.5 *Pointer and pointer-stop*, for the registering the maximum arc through which the pendulum-sector swings when released. The pointer is mounted on the same axis as the pendulum-sector, there being constant friction just sufficient to stop the pointer at the highest point reached by the swing of the pendulum-sector. The adjustable pointer-stop provides a means for setting the zero of the apparatus.

4.1.6 *Levelling screws*, for levelling the apparatus.

4.1.7 *Cutting die (specimen size)*, having essentially the shape and dimensions shown in figure 1. The die is used to cut out the basic rectangular test specimen that is 100 mm ± 2 mm long and 63 mm ± 1 mm wide, plus an additional 8 mm of fabric at the top edge of the specimen to ensure that the last portion of the fabric is torn (not ravelled) and 4 mm of fabric at the bottom edge as an aid to centring it in the jaws.

4.1.8 *Means of making a slit*, of 20 mm ± 0.5 mm in the centre of the bottom edge of the specimen to initiate the tear. The slit may be cut by the cutting die (5.1.7) or, alternatively, the initial cut may be made by a knife (that is mounted on the apparatus) when the specimen is in place.

4.2 Capacity and Accuracy

The apparatus shall be of suitable capacity so that the tearing occurs between 20 percent and 80 percent of the full-scale force It shall also meet the following requirements:

Scale error	<	1%
Zero error	<	0.5% of full scale load
Zero stability	<	1% of full scale load
Pointer friction	<	3 and > 2 scale divisions
Pendulum friction	>	35 oscilations

4.3 Adjustment and Maintenance

The apparatus shall be maintained properly and adjusted regularly in accordance with the instructions of the manufacturer. A brief description of adjustment and maintenance of an apparatus functioning on the above principle is given in Annex A.

5 PREPARATION OF TEST SPECIMENS

5.1 Sampling

The test sample shall be taken from a laboratory bulk sample that is representative of the lot to be tested. The test sample shall not be cut within 2 m of the ends of a piece nor closer than 50 mm to a selvedge.

The critical dimensions of the test specimen are the distance of 43 mm ± 0.5 mm that is to be torn during the test, and the distance above the clamp of the end of the pre-cut slit of 4.0 mm ± 0.5 mm.

For method A, cut specimens as shown in Fig. 1. For method B, cut specimens 100 mm ± 2 mm by 63 mm ± 1 mm.

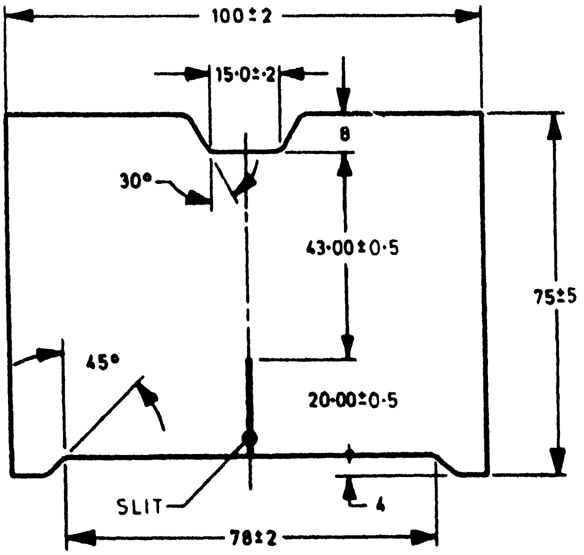


FIG. 1 CUTTING DIE

NOTE — For some apparatus the appropriate dimensions vary, particularly in the width of the test specimen. If specimens with widths other than those specified are used, this shall be stated in the test report.

5.2 Test Specimens

One set of not less than five specimens shall be cut for each direction to be tested, using the cutting die (**4.1.7**). The set for the warp tear tests (that is tearing across the warp threads) shall have the shorter dimension parallel to the weft threads, and the set for weft tear tests (that is tearing across the weft threads) shall have the shorter dimension parallel to the warp threads. Each set of specimens shall be cut from the sample in such a manner that no two specimens in the set include the same threads. In preparing the specimens, care shall be taken to align the threads running in the short direction parallel to the die so that when the slit is cut, the subsequent tear will take place between these threads and not across them. This precaution is most important when testing bowed fabrics.

6 ATMOSPHERE FOR CONDITIONING AND TESTING

The specimens shall be conditioned to moisture equilibrium and testing shall be conducted standard atmospheres at 65 ± 2 percent relative humidity and 27 ± 2°C temperature (*see* Section B-1/1).

7 PROCEDURE

7.1 Preparation of Apparatus

7.1.1 Before testing, level the apparatus with the levelling screws (**4.1.6**) and check both the equilibrium position of the pendulum-sector and zero reading.

7.1.2 Select the capacity of the apparatus (**4.2**) according to the fabric under test, so that the specimens tear between 20 percent and 80 percent of the full-scale value. Carry out a preliminary test, if necessary, to determine the appropriate range.

7.2 Test Procedure for Method A

7.2.1 Raise the pendulum-sector (**4.1.1**) to the starting position. Secure it by the pendulum-sector release mechanism (**4.1.4**) and set the pointer against its stop (**4.1.5**).

7.2.2 Clamp a specimen securely in the jaws (**4.1.3**) so that it is centred with the botton edge set against the stops and the upper edge parallel to the top of the jaws. Close the jaws by tightening the setting screws, using approximately the same tension on both, where applicable operate the knife (**4.1.8**) to make the initial slit in the lower edge of the specimen. The specimen shall lie free with its upper edge directed towards the pendulum-sector so as to ensure a shearing action.

7.2.3 Depress the pendulum-sector release mechanism as far as it will go and hold it down until tearing is completed (This is particularly important in order to prevent the pendulum stop from interfering with the initial swing of the pendulum-sector). Catch the pendulum-sector by hand on the return swing without disturbing the position of the pointer.

7.2.4 Record the position of the pointer as indicated by the nearest whole scale division for the capacity used.

7.2.5 Repeat operations 7.2.1 to 7.2.4 on the remaining test specimens.

7.2.6 Discard readings obtained when the specimen slips in the jaws or where tearing deviates beyond the base of the slit in such a way that the tear is not completed in the notch at the top of the specimen.

7.3 Test Procedure for Method B

Carry out the procedure generally as described in 7.2 but, after mounting the specimen on the apparatus, make a slit using the means provided (4.1.8).

8 EXPRESSION OF RESULTS

8.1 Record the Tearing Force in Newtons

NOTE — Depending on the type of apparatus used, this may mean multiplying the scale reading obtained by an appropriate factor as specified by the manufacturer of the test apparatus.

8.2 Calculate and record the average force, in newtons, required to tear the test specimens across:

- the warp threads; and
- the weft threads.

8.3 If required, calculate the coefficients of variation of the results.

9 TEST REPORT

The test report shall include the following:

a) that the test was conducted in accordance with the method A or B;
b) the type of material tested;
c) the number of readings in both warp and weft directions;
d) the individual values and the average tearing force, in newtons, for each direction of tear and, if required, the coefficient of variation for each direction of tear; and
e) the number of tests rejected because of crosswise tearing or for other reasons.

ANNEX A

(*Clause* 4.3)

ADJUSTMENT AND MAINTENANCE OF THE APPARATUS

A-1 GENERAL

Follow the procedure described in **A-2** to **A-6** for each of the pendulum/additional-mass combinations used.

A-2 INSPECTION

Check the following items and make any necessary adjustments:

a) check that the pendulum shaft (**4.1.1**) is not bent;

b) check that the distance between clamps (**4.1.3**) is 2.8 mm ± 0.4 mm and that, when the pendulum is in its initial position, the clamps are aligned;

c) check that the knife (**4.1.8**) fitting is secure, and that cutting edge is sharp and undamaged (the blade should be situated midway between, and at right angles to the top of the clamps); and

d) ensure that the pointer (**4.1.5**) is undamaged and is rigidly attached to the sleeve.

A-3 LEVELLING

A-3.1 Mount the apparatus on a rigid bench; if possible, firmly attach it to the bench.

A-3.2 With the pendulum clamp closed, adjust the apparatus with the help of the levelling screws (**4.1.6**) so that the pendulum hangs vertically and the index marks on the pendulum and base coincide. With the stop (**4.1.5**) depressed, displace the pendulum slightly and, after it comes to rest, check that the index marks still coincide.

A-4 ZERO ADJUSTMENT

After levelling, operate the apparatus several times with the clamps empty and closed to ascertain whether the pointer registers zero. If zero is not registered, move the adjustable pointer stop.

A-5 PENDULUM FRICTION

A-5.1 Make a reference mark on the stop mechanism (**4.1.4**) 25 mm to the right of the edge of the pendulum catch. Raise the sector to its initial position and set the pointer so that it does not meet the pointer stop when the apparatus is in operation.

A-5.2 When the sector is released and the pendulum stop held down, the sector should make at least 35 complete oscillations before the edge of the sector which engages with the catch no longer passes to the left of the reference mark. Otherwise, clean, oil or adjust the bearing.

A-6 TEARING LENGTH

The tearing length shall be 43.0 mm ± 0.5 mm. If this is not the case, adjust the dimensions of the guilotine or template used.

DETERMINATION OF SEAM STRENGTH OF JUTE FABRICS INCLUDING THEIR LAMINATES

(*Source* : IS 9030:1979)

The performance of made-up items such as bags and tents of jute fabrics and their laminates depends on the seam strength which is affected by the type of seam, sewing threads, etc, used for giving them the intended shape.

This method of test is suitable for determining the behaviour of seams under stress. It does not give details of sewing conditions which should be agreed to between the concerned parties or specified in the relevant specifiation for made-up finished materials. In case it is intended to compare the seam breaking load values with the fabric breaking load values, it would be advisable to use the same size of the test specimens in both the cases.

1 SCOPE

1.1 It prescribes a method for determination of seam breaking strength of seams when the load is applied perpendicularly to the seam using strip method and grab method.

1.2 The sewn seams may be obtained from the previously sewn articles, such as bags, tents, etc, or may be prepared from fabric samples. This method is applicable to seams in straight line only and not to curved seams.

2 PRINCIPLE

A rectangular test specimen is prepared with the seam at the middle of the specimen. The specimen is gripped between the two jaws and a longitudinal force perpendicular to the seam is applied till the specimen breaks. The maximum breaking load of the test specimen is recorded.

3 SAMPLING

The sampled from the previously prepared articles shall be so drawn as to be representative of the lot. Samples drawn in accordance with the procedure laid down in the specifiation of the material shall be taken as representative of the lot.

4 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

Prior to test, the specimens shall be conditioned to moisture equilibrium in the standard atmosphere of 65 ± 2 percent relative humidity and 27 ± 2°C temperature from dry side as laid down in IS 6359:1971 'Method for conditioning of textiles' given in Section B-1/1 and the test shall be carried out in the standard atmosphere.

5 PREPARATION OF TEST SPECIMENS

5.1 From each sample cut test specimens with the length across the seam and the width parallel to the seam. The size of the specimen shall be as given in Table 1 when read with Fig.1 for strip method and Fig. 2 for grab method. The seam shall be at the middle of the specimen.

NOTE — In case of fabrics where the seams are to be prepared for testing, the concerned parties should agree to the conditions of sewing before testing.

5.1.1 In case of ravelled strip, care shall be taken that wherever possible no thread perpendicular to the seam is cut in the final width of the specimen.

5.1.2 In the case of grab method, draw a line perpendicular to the seam at 37 mm away from one edge of the specimen as shown in Fig. 2.

5.2 In case the seams are in both warp and weft directions of the fabric separate specimens shall be prepared and marked with 'W' for warp and 'F' for weft, for identification purposes.

Table 1 Size of Test Specimens and Jaw Faces

(*Clauses* 5.1, 6.1 *and Figs.* 1 *and* 2)

All dimensions in millimetres.

Type of Test	Size of Test Specimen Length (*Min*) ×Width	Size of Jaw Faces	Gauge Length
(1)	(2)	(3)	(4)
Strip test*	350 × 100	100 × 25 or more	200
Grab test	150 × 100	25 × 25 or more	75

---

* Effective width after ravelling/cutting = 50 mm.

6 TESTING MACHINE

6.1 A tensile testing machine provided with the following arrangements shall be used:

a) Two clamps, each of which shall:

1) consist of two metallic jaws (*see* Table 1) and each jaw face shall be in line both with respect to its mate in the same clamp and to the corresponding jaws of the other clamp; and
2) be provided with a mechanical device so constructed that through its means a specimen can be secured firmly between the jaws of the clamps so that it does not slip during the test. Also, the edge of the surface of each jaw shall be such that it would not cut or damage the specimen during testing.

NOTE — The faces of the jaws are generally flat, engraved or corrugated. To avoid the chances of slippage or damage to the specimen, packing materials like paper, felt, leather, plastic or rubber sheet may be used.

b) Means for adjusting the distance between the clamps.

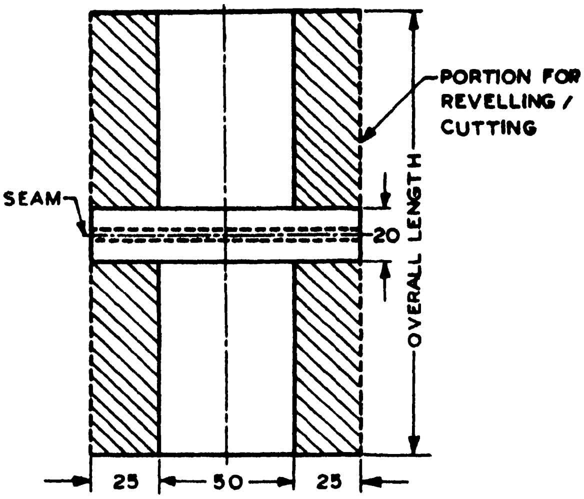
c) Means for driving by power one of the pair of clamps at a specified constant-rate-of-traverse, loading or elongation, as the case may be, so that the test specimen breaks in 20 seconds ± 10 seconds.

NOTE — If the arrangement for breaking the specimen within 20 seconds ±10 seconds is not there, the test shall be carried out at a constant-rate-of-traverse machine (which is very popular and widely used in India) at the rate of 300 mm ± 15 mm/min. In case of jute fabrics, the rate-of-traverse shall be 300 mm ± 15 mm /min for grab test and 460 mm ± 15 mm/min for ravelled-strip and cut-strip method of test.

d) A scale or dial or autographic recording chart graduated so as to give load in newtons/kilograms.

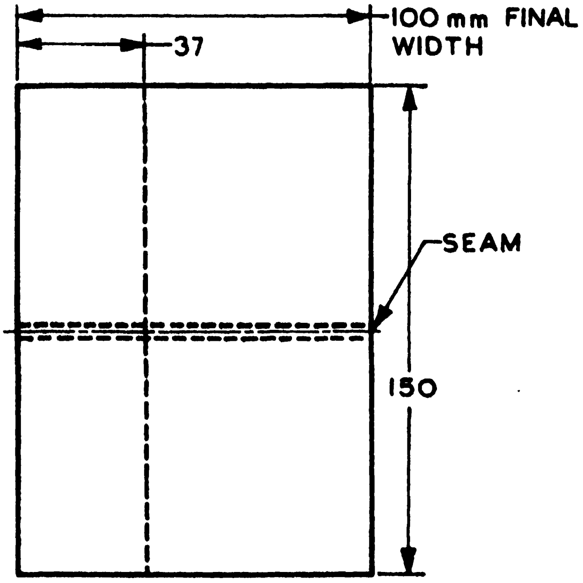
6.1.1 The load range of the machine shall be such that all the observed values would lie between 10 and 90 percent of the full-scale load. The permissible error in the machine at any point in this range shall not exceed ±1 percent.

6.2 A pair of scissors or a sharp blade, measuring scale, stop watch, etc.



All dimensions in millimetres.

FIG. 1 SHAPE AND DIMENSIONS OF TEST SPECIMENS (STRIP METHOD)



All dimensions in millimetres.

FIG. 2 SHAPE AND DIMENSIONS OF TEST SPECIMENS (GRAB METHOD)

7 PROCEDURE

7.1 Set the clamps of the testing machine so that the distance between them is 200 mm for strip method and 75 mm for grab method. Take a test specimen and insert it in the clamps of the testing machine so that its longer side is parallel to the direction of application of load with approximately the same length of the fabric extending beyond the jaws of at each end and the seam in the middle of the two clamps. In the case of grab method the line drawn along the length of the specimen (**5.1**) must coincide with the left hand side of the 25 mm wide jaws. Secure the test specimen between the jaws of one of the clamps. Through the free end of the specimen, apply a tension of about one percent of the expected breaking load, and secure it between the jaws of the other clamp.

7.2 Operate the machine and carry the test to rupture and record the breaking load of the specimen Also record whether the seam rupture is caused by: (a) fabric yarn breakage, (b) sewing thread breakage, (c) fabric yarn slippage, or (d) a combination of two or more of these reasons.

NOTE — If the specimen slips in the jaws breaks in the jaws or breaks within 5 mm from the edge of the jaws the results shall be discarded but recorded and another specimen tested *in lieu* thereof

7.3 Open both the clamps and remove the broken specimen. Take a fresh specimen and determine its breaking load as given in **7.1** and **7.2** and repeat the test with the remaining test specimens. The number of test specimens shall be according to the material specifiation.

8 CALCULATIONS

Calculate the mean breaking load, in newtons/kilograms, of all the test specimens excluding rejections separately for warpway and weftway.

9 REPORT

The report shall include the following information:

a) Description of the material tested;
b) Number of specimens tested;
c) Number of specimens breaking due to:
    1) fabric yarn breakage;
    2) sewing thread breakage;
    3) fabric yarn slippage;
    4) sewing yarn slippage; or
    5) combination of two or more of the above.
d) Number of tests rejected,
e) Mean breaking load of seam;
f) Type of test (cut strip, revelled strip or grab);
g) Type of stitch (if applicable);and
h) Type of machine used.

DETERMINATION OF RECOVERY FROM CREASING OF TEXTILE FABRICS BY MEASURING THE ANGLE OF RECOVERY

(*Source* : **IS 4681:1981**)

The ability of a fabric to retain pressed-in creases and to recover from creasing is an important property, especially in case of apparel fabrics. The need for standardizing a method for evaluating crease recovery of different fabrics has been increasingly felt with the introduction of crease resistant fabrics. When creasing force is removed from the creased fabric, it tends to recover and the creases in the fabric start diminishing at varying rates. The magnitude of the crease recovery angle as measured according to this standard is taken as an indication of the ability of a fabric to recover from creasing.

1 SCOPE

1.1 It prescribes a method for determination of crease recovery of fabrics by determining the angle of recovery after the removal of creasing force. The method is especially intended for apparel fabrics.

1.2 This method is not very suitable for weft knitted fabrics as well as limp or very thick fabrics, or fabrics having tendency to curl, since these factors influence the test results to an unacceptable degree.

2 PRINCIPLE

A crease-free rectangular specimen of prescribed dimensions is folded in half so that the two limbs of the strip touch each other face to face, under a specified load and maintained in the state for a specified period. After the creasing load is removed, the specimen is allowed to recover for a specified time. At the end of recovery period the angle of recovery is measured.

3 TERMINOLOGY

For the purpose of this standard, 'Crease Recovery Angle' shall mean the angle formed between the two limbs of a strip of fabric previously folded to form a single crease under prescribed conditions, at a specified time after removal of creasing load.

4 SAMPLING

4.1 Lot

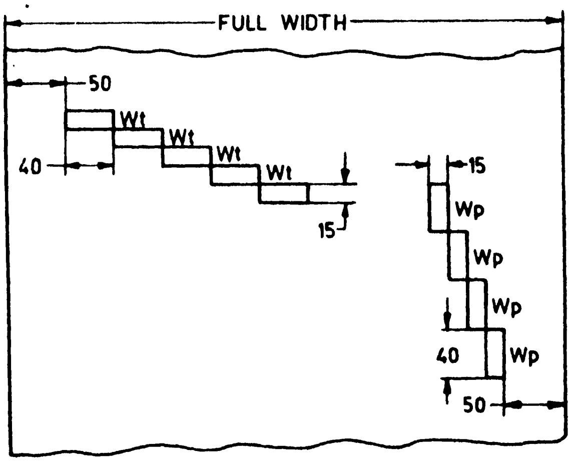
The quantity of fabric purported to be of one definite composition, construction and quality delivered to one buyer against one despatch note.

4.2 Sample drawn in compliance with the specification for the material shall be held to be representative of the lot.

5 PREPARATION OF TEST SPECIMENS

5.1 Cut warpway (W_p) and weftway (W_t) test specimens of 15 mm × 40 mm size (*see* **9.4**) with the help of sharp pair of scissors or blade with their longer side parallel to warp and weft threads respectively. The specimens shall be staggered in such a way that no two warpway specimens contain the same set of weft yarns. The specimens shall not be taken from creased, wrinkled, bent or other deformed parts of the sample and also not from within 50 mm from the selvedges. One possible layout of cutting warp way and weftway test specimens from one test sample is given in Fig. 1.

NOTE — Warpway test specimens (that is, with longer side parallel to warp threads) are used for measuring angle of crease recovery across warp threads and similarly weftway test specimens are used for measuring angle of crease recovery across weft threads.



W_p = Warp test specimens

W_t = Weft test specimens

All dimensions in millimetres.

FIG. 1 LAYOUT OF TEST SPECIMENS

5.2 In case of warp knitted and non-woven fabrics, the direction parallel to wales (knitted fabrics) and the direction marked ' length ' (non-woven fabrics) shall be treated as warp direction and the direction parallel to courses (knitted fabrics) and direction perpendicular to 'length' (non-woven fabrics) shall be treated as weft direction and the specimens prepared in the same way as in **5.1** for woven fabrics.

5.3 Number of Specimens

Not fewer than 20 specimens-10 warpway and 10 weftway among which 5 specimens each face to face and back to back respectively across both warp and weft are to be taken for testing.

5.4 Wet Specimens

In case it is desired to test the specimens in wet state, take the specimens and dip in a solution containing 0.1 percent (*m/v*) detergent for one minute. Remove the specimens with the help of a forceps and put them on the layers of a good absorbent cloth. Soak the excess water by blotting with blotting paper and applying a load of 500 g for a minute and then test.

6 CONDITIONING OF TEST SPECIMENS

Prior to test, the specimens shall be conditioned to moisture equilibrium from dry side in a standard atmosphere of 65 ± 2 percent relative humidity and 27 ± 2°C temperature (*see also* IS 6359:1971 given in Section B-1/1).

NOTES

1 When the test specimen has been left in standard atmosphere for at least 24 hours is such a way as to expose as far as possible all portions of the specimens to the atmosphere, they shall be deemed to have been conditioned satisfactorily.

2 It is preferable to store newly finished fabrics for about a week before conditioning

7 ATMOSPHERIC CONDITIONS FOR TESTING

The test shall be carried in the standard atmosphere (*see* **6.1**).

8 APPARATUS

8.1 Crease Recovery Tester

The instrument shall consist of the following essential parts:

a) *A Circular Scale* in the vertical plane, graduated in degrees along its periphery and capable of being read to an accuracy of ±0.5° without parallax error.

b) *Specimen clamp* to hold one limb of the specimen in such a way that the fold like in a horizontal line on the axis of the circular scale, while the distance between the edge of the grip and the axis shall be about 2 mm. The clamp shall be rotatable so as to adjust the free limb of the specimen in the vertical or horizontal position, depending upon the type of instruments used.

c) Means for levelling the apparatus.

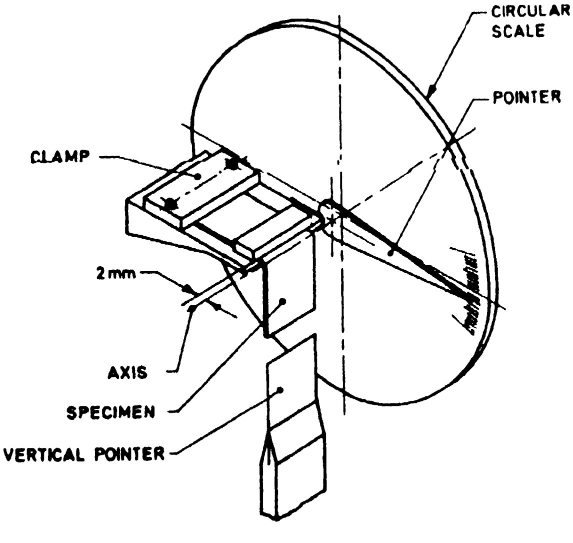


FIG. 2 INSTRUMENT FOR MEASURING THE CREASE RECOVERY ANGLE

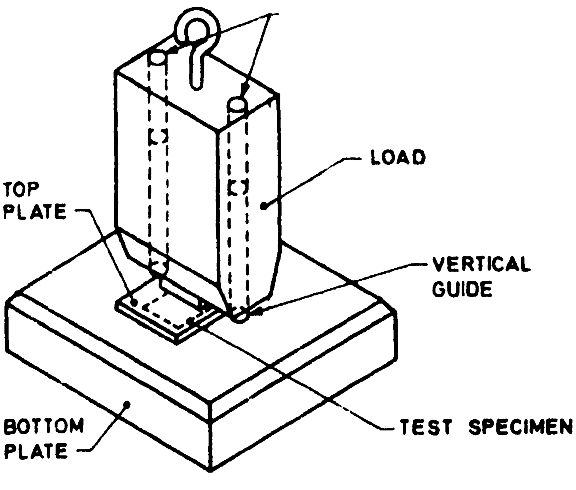


FIG. 3 APPARATUS FOR LOADING TEST SPECIMEN

NOTE — An outline of the principal parts of a crease recovery tester working on the above principle is given in Fig. 2.

8.2 Loading Arrangement

It shall be capable of applying a load of 1 kg uniformly over 15 mm × 15 mm area of the folded specimen. The arrangements for applying and removing the load shall be such that these operations could be done expeditiously.

NOTE — An outline of the simply loading device is given in Fig. 3.

8.3 Auxiliary Devices

Stop watch tweezers with broad spade shaped jaws.

9 PROCEDURE

9.1 Level the testing equipment with the help of levelling screws and spirit level. The testing equipment shall be screened from draughts, operator's breath and excessive heat radiation from lighting appliances.

9.2 Loading

Fold the specimen end to end in half with its edges gripped in one line with the help of tweezers no more than 5 mm from the ends (*see* Fig.4) Place the folded specimens on the plate of the loading device and apply load gently without delay. Remove the load after 5 minutes. The removal of load shall be completed within 0.5 second.

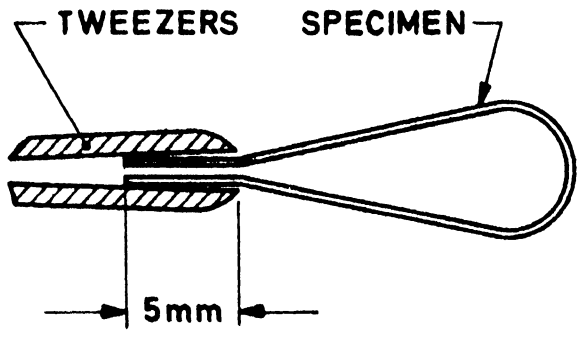


FIG. 4 FOLDING OF SPECIMEN

9.2.1 Half the number of test specimens (both in case of warpway and weftway test specimens) shall be folded face to face and the other half back to back.

9.3 Measurement of Recovery Angle

After the load is removed, transfer the specimen directly to the clamp of the instrument or place it on edge on a smooth horizontal surface. For mounting the specimen in the clamp, hold one limb of the specimen in the tweezers and place the other limb in the clamp of the instrument in such a manner as to cause as little disturbance to the angle as posible. If the specimen stands on edge, the mounting of the specimen in the clamp shall be done so that it remains in the clamp at least for 1 minute before the angle is measured.

9.3.1 While the specimen is in the clamp, continue adjusting the clamp in such a way that the suspended limb of the specimen is always in a vertical position or horizontal position depending upon the type of instrument used. Take the reading of the crease recovery angle after 5 minutes from the removal of the load.

NOTE — If the free limb is not flat, the vertical plane through its centre and the axis of the circular scale (dial) shall be taken as basis for the reading of the crease recovery angle.

9.4 Measure the angle of recovery for all the warpway (W_p) and weft-way (W_t) specimens folded face to face and back to back in the same way. Test at least 10 warpway and 10 weftway test specimens for the test.

10 EVALUATION OF RESULTS

Calculate the mean value of crease recovery angle to the nearest degree by taking in each instance the test result of 5 specimens, face to face and back to back respectively, across both warp and weft.

11 REPORT

The report shall include the following information:

a) Name of the instrument used;
b) The type of fabric tested;
c) State of specimen (wet or dry);
d) Number of tests performed;
e) Mean value of crease recovery angle :
    1) Across warp (W_p);
    2) Across weft (W_t); and
    3) Warp and weft total.
f) If required, standard deviation and confidence interval for each case.

NOTE — If the difference between two readings of face-to-face and back-to-back specimens is more than 10°, then the results for face-to-face and back to back specimens shall be reported separately.

DETERMINATION OF PILLING RESISTANCE OF FABRICS

(*Source* : IS 10971:1984)

Fabrics made from certain fibres and fibre blends may develop during the course of wear tufts of entangled fibres, attached to the surface of the cloth and looking like small pills. Although a number of methods have been developed for determining the pilling properties of fabrics, it is difficult to simulate the wear conditions by any single machine. Testing of this characteristic is important especially for fabrics meant for garments like sweaters, shirts, blouses, lingeries, trousers, suits and skirts.

1 SCOPE

It prescribes a method for determination of pilling resistance of fabrics by tumble type pilling tester. This method may not be suitable for fabrics containing fancy yarn like slub yarn, gimp yarn and fleece yarn.

2 PRINCIPLE

The fabric samples are mounted on rubber tubes and put in a cubical box revolving at a known speed for a fixed time. The samples are then removed and compared against standards.

3 SAMPLING

The samples for test shall be drawn as laid down in the material specification or as agreed to between the buyer and the seller. The samples drawn shall be representative of the lot.

4 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

4.1 Prior to evaluation the samples shall be conditioned to moisture equilibrium in the standard atmosphere at 65 ± 2 percent relative humidity and a temperature of 27 ± 2°C as laid down in IS 6359:1971 'Method for conditioning of textiles' given in Section B-1/1. The test shall also be carried out in the standard atmosphere.

5 APPARATUS

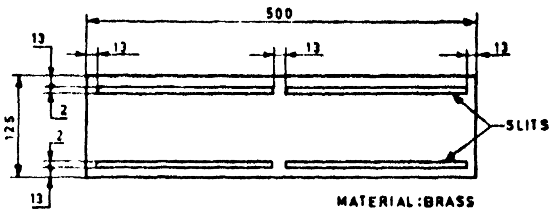
5.1 Tumble Pilling Tester

Having cubical boxes of 225 mm internal side length. The inner walls of the boxes shall be lined with 3 mm thick cork lining. The mass/cm^2 of the cork lining shall be 0.085 g. The boxes shall be capable of rotating at a constant speed of 60 rev/min about a horizontal axis passing through the centres of two opposite faces. The tester shall be provided with arrangements for stopping it after pre-determined number of revolutions.

NOTE — The cork lining shall be replaced only when it appears to be severely worn out or soiled

5.2 Template for Cutting Specimens

See Fig. 1.



All dimensions in millimetres

FIG. 1 TEMPLATE FOR TEST SPECIMENS

5.3 Rubber Tubes

Of 150 mm length, 32 mm outer diameter and 3.2 mm wall thickness, having Shore A hardness of 55 to 60 degrees.

5.4 Specimens Mounting Accessories

Comprising jig, metal cylinder, etc, as shown in Fig. 3.

5.5 Photographic Rating Standards

A set of 5 photographs, 110 mm × 95 mm in size, numbered as 1 to 5 showing varying degrees of pilling from 'very severe pilling', to 'no pilling', as given in Annex A.

6 PREPARATION OF TEST SPECIMENS

6.1 Place the fabric facing downwards on a plain surface and on it place the template (*see* Fig.1) with its longer edges along the weft direction. Draw lines with the help of a pencil around the edges and in the slits of the template. Then cut the fabric along the outer lines so that a sample measuring 125 mm × 500 mm is obtained.

6.2 Fold the sample with the face inwards until the longer edges touch each other and sew exactly along the inner pencil lines (*see* Fig. 2).

NOTE — This ensures that all specimens of one type of fabric have the same tension when finally mounted upon rubber tubes

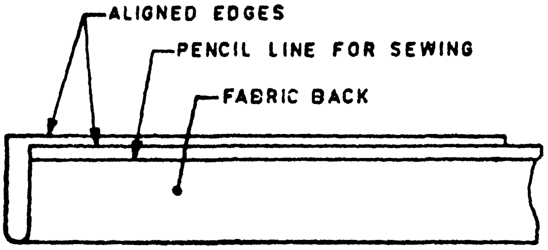


FIG. 2 SPECIMEN DURING PREPARATION

6.3 Cut from the sewn sample 4 specimens along the length, each 125 mm long. Turn the specimens inside out so that the face side of the fabric is outside.

7 MOUNTING OF TEST SPECIMENS

7.1 Take a rubber tube (5.3) and the specimen mounting accessories (5.4). Place the rubber tube over the rods (*see* Fig. 3A) of the jig. Pull the tube around rod B (*see* Fig. 3B) and push the hollow metal cylinder with a tapered end plug (*see* Fig. 3C) over the folded rubber tube (*see* Fig. 3D). Push the fabric specimen over the metal cylinder (*see* Fig. 3E) and then withdraw the cylinder with a turning motion leaving the collapsed rubber tube surrounded by the test specimen (*see* Fig. 3F). Withdraw the rubber tube from the jig and allow it to recover to its original circular configuration with the fabric specimen wrapped around it under even tension (*see* Fig. 3G).

NOTE — To prevent fraying of cut ends of the specimen, cover the cut ends with adhesive transparent tape (12 mm wide), wound round the tube, overlapping the fabric on each end by about 6 mm

7.2 Prepare at least 4 such test specimens.

8 PROCEDURE

8.1 Clean the boxes thoroughly. Place four mounted test specimens in each box and close the boxes. Set the machine for 18 000 revolutions. Start the machine and let it run till it automatically stops.

8.2 Take out the specimens and compare them with the photographic rating standards.

9 EVALUATION

Evaluate the test specimens against the photographic rating standards given in Annex A in a well-lighted place avoiding glare and report the ratings separately for each specimen.

NOTE — Photographic rating standards show the following extents of pillings

Rating 1	Very severe pilling
Rating 2	Severe pilling
Rating 3	Moderate pilling
Rating 4	Slight pilling
Rating 5	No pilling

In each case the specimen may or may not also become hairy, but any hairiness of the fabric is not, however, taken into account in the assessment. If the fabric becomes hairy, the letter H be added after the numerical value of its rating, such as 1 H or 2 H. Provision may also be made for rating the specimens as 1-2, 2-3, etc, according as the rating falls between 1 and 2, 2 and 3, etc.

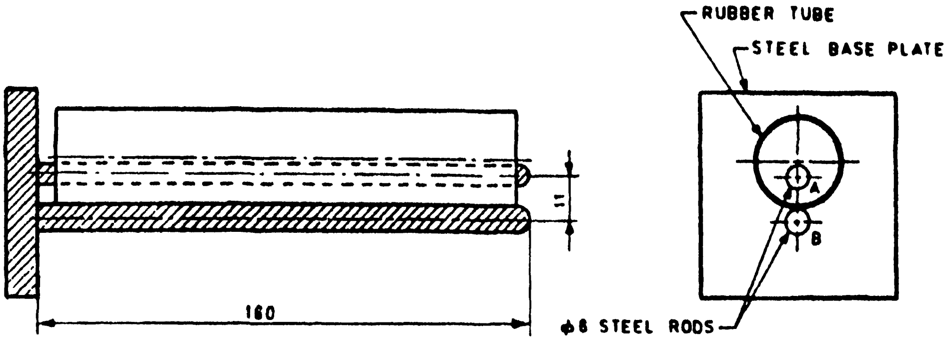
10 REPORT

The report shall include the following information:

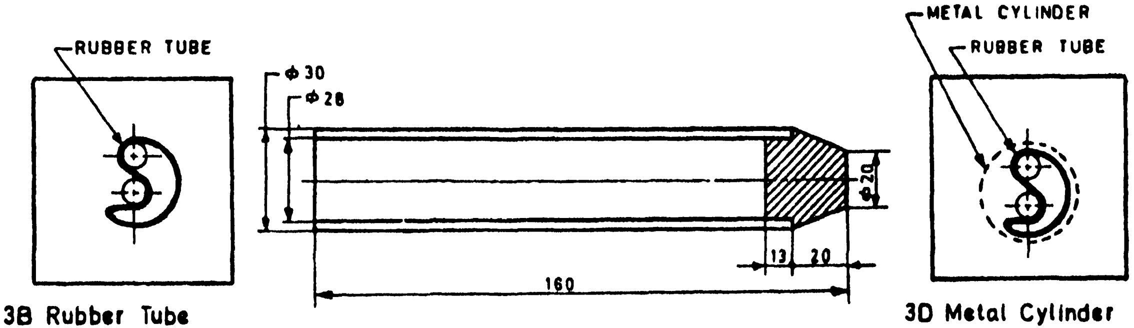
a) Type of fabric,

b) Number of specimens tested, and

c) Rating of each specimen.



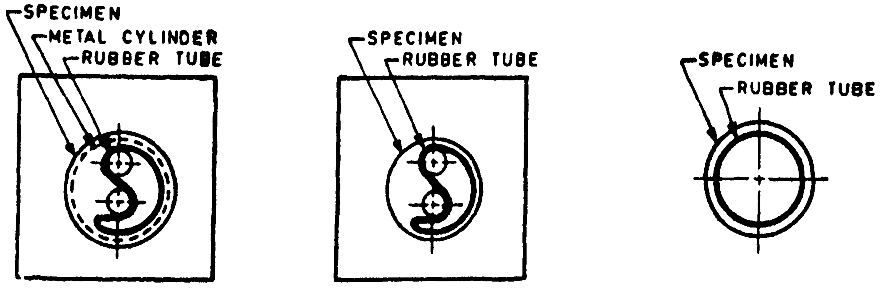
3A Jig With Rubber Tube



3B Rubber Tube Pulled Round Rod B

3C Metal Cylinder With Solid Metal End Plug

3D Metal Cylinder Placed Over Rubber Tube



3E Specimen Drawn Over The Metal Cylinder

3F Metal Cylinder Withdrawn, Leaving Specimen Outside Folded Rubber Tube

3G Mounted Specimen After Withdrawal From Jig

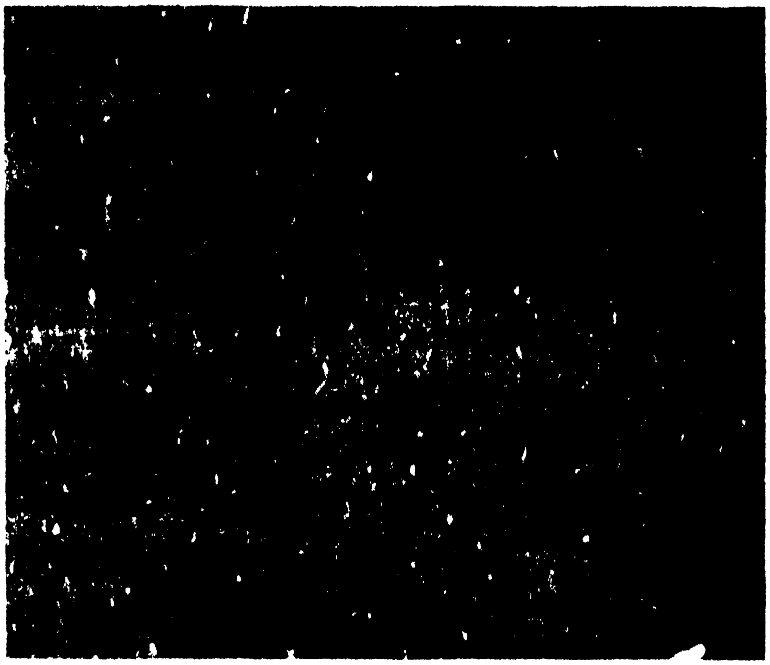
All dimensions in millimetres

FIG. 3 SPECIMEN MOUNTING PROCEDURE

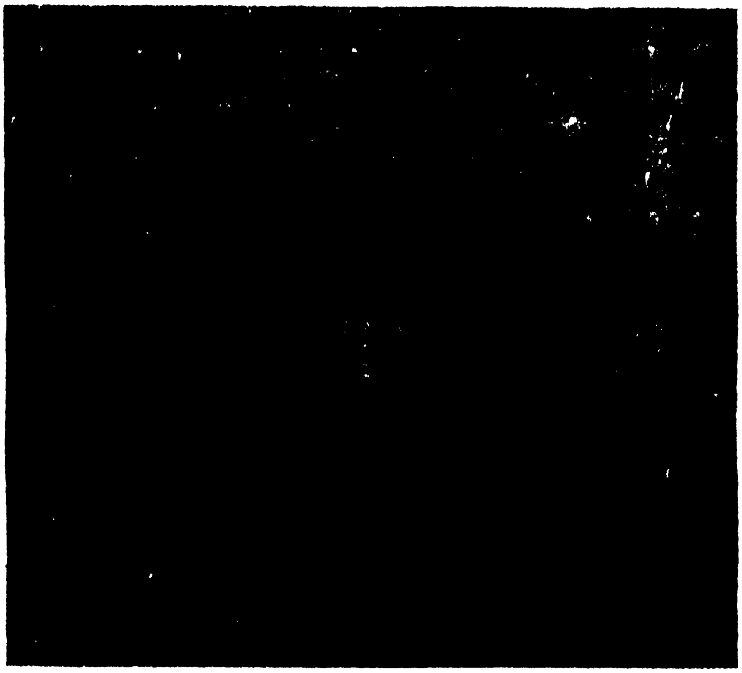
ANNEX A

(*Clauses* 5.5, 8.2 *and* 9.1)

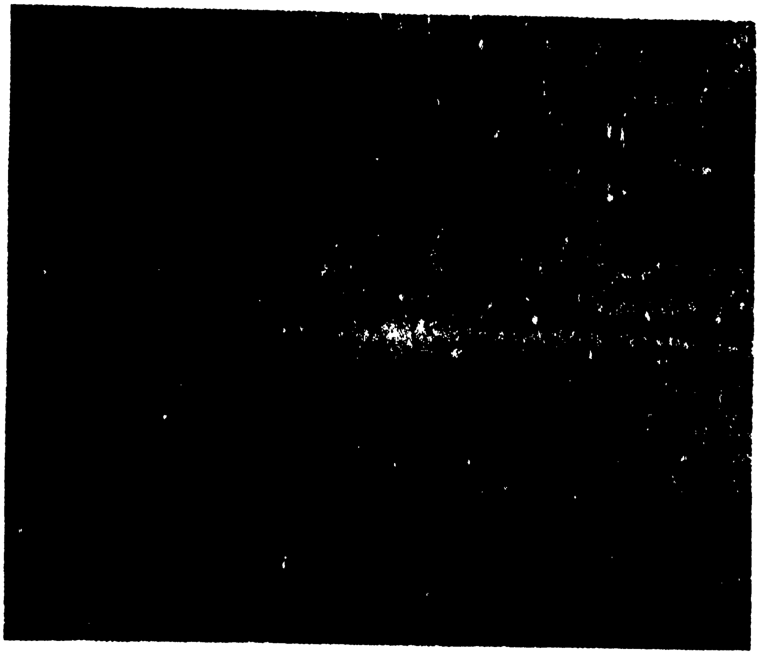
PHOTOGRAPHIC RATING STANDARDS FOR PILLING



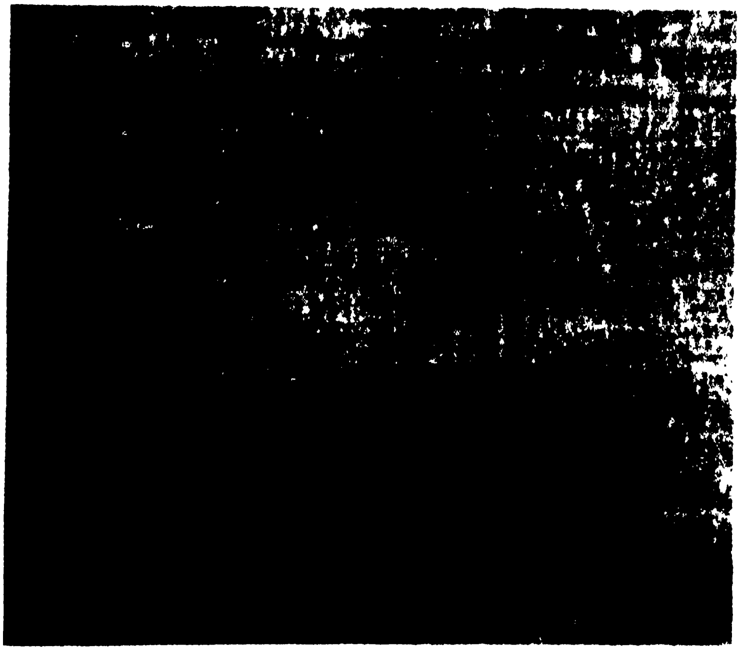
RATING 1 VERY SEVERE PILLING



RATING 2 SEVERE PILLING



RATING 3 MODERATE PILLING



RATING 4 SLIGHT PILLING

RATING 5 NO PILLING

DETERMINATION OF AIR PERMEABILITY OF FABRICS

(*Source* : **IS 11056:1984**)

Air permeability is an important feature for fabrics used for special technical purposes such as filter cloths, felts, impregnated fabrics, membranes, parachutes, packing materials, etc. Air permeability may also be used for clothing fabric to indicate their breathability.

1 SCOPE

It prescribes a method for measuring the permeability of fabrics to air and is applicable to industrial fabrics that are permeable to air. However, the method is not suitable for parachute fabrics.

2 PRINCIPLE

The method is based on the measurement of the rate of flow of air through a given area of fabric by a given pressure drop across the fabric.

3 TERMINOLOGY

For the purpose of this standard, air permeability shall mean the volume (cm^3) of air passing through 1 cm^2 of fabric per second at a pressure difference of 1 cm head of water.

4 SAMPLING

Samples drawn in accordance with the procedure laid down in material specification for the fabric or as agreed to between the parties concerned shall be held to be representative of the lot.

5 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

Prior to test, the samples shall be conditioned to moisture equilibrium in the standard atmosphere of 65 ±2 percent relative humidity and 27 ± 2°C temperature from dry side as laid down in IS 6359:1971 (*see* Section B-1/1). The test shall be carried out in the standard atmosphere.

6 APPARATUS

6.1 The apparatus shall consist of the following arrangements:

a) Means for drawing or forcing air through the fabric of known area.

b) Circular orifice of definite known area.

c) Provision to hold the fabric so that there is no peripheral leakage of air.

d) Means for adjusting the pressure drop across the fabric to a known amount.

e) Means for measuring the rate of flow of air through the fabric.

f) Means for checking the calibration of air flow meter (*see* Annex A).

6.1.1 It is desirable that the apparatus shall be capable of testing large pieces of fabrics without cutting.

7 PROCEDURE

7.1 Take the conditioned specimen and mount a portion between the clamp and circular orifice with sufficient tension to eliminate wrinkles, if any, taking care to see that the fabric is not distorted in its own plane.

7.2 Start the suction fan or other means to force the air through the fabric and adjust the rate of flow of air till pressure drop of one centimetre water head across the fabric is indicated.

7.3 Note the rate of flow of air in cm^3/s.

7.4 Repeat the test at other different places. In all, at least 10 tests shall be carried out.

8 CALCULATION

Calculate the rate of flow of air per cm^2 of fabric in cm^3/s by the following formula:

$$R = \frac{r}{A}$$

where

R = rate of flow of air/cm^2 of fabric in cm^3/s,

r = mean rate of flow of air in cm^3/s, and

A = area cm^2 of fabric under test in cm^2.

9 REPORT

The report shall include the following information:

a) Type of fabric tested;

b) Name of the instrument used;

c) Number of tests recommended;

d) Average air permeability value (cm^3/cm^2/s); and

e) C. V. percent.

ANNEX A

[*Clause* 6.1 (f)]

CALIBRATION OF AIR FLOW INSTRUMENTS

A-1 GENERAL

A-1.1 Air flow instruments are very sensitive instruments and therefore require delicate and careful handling to avoid malfunctioning. Malfunctioning of the instruments can be caused by air leakage, physical damage to the nozzle or test plate, wornout condition of the gasket or over flow of liquid in the manometer, etc.

A-2 CALIBRATION

A-2.1 Different instruments are provided with different means and acessories for the calibration and checking of the air flow instruments, like steel plates with holes to give pre-determined air flow values, capillary resistances having pre-determined air flow values to be used in conjunction with roto meters, set of nozzles and plates, etc. Before using the instruments, check and calibrate with the help of the calibration accesories provided with the instruments as per the instructions given in the Instrument Manual.

DETERMINATION OF STIFFNESS OF FABRICS — CANTILEVER TEST

(*Source* : IS 6490:1971)

1 SCOPE

1.1 It prescribes a method for determination of stiffness of fabrics made from any textile fibre or a blend of two or more textile fibres.

1.2 This method of test is not suitable for fabrics which are very limp or which curl or twist badly when cut into small pieces; in general, this method is more suitable for testing woven fabrics than for testing knitted ones.

2 PRINCIPLE

The principle employed is to measure a particular length of the fabric specimen of specified dimensions which when used as a cantilever bends to a constant angle under its own weight.

3 TERMINOLOGY

For the purpose of this test method, the following definitions shall be used.

3.1 Stiffness

Resistance of fabric to bending.

3.2 Flexural Rigidity

Ratio of the small change in bending moment per unit width of the material to the corresponding small change in the curvature, expressed in milligram centimetres (mg-cm).

3.2.1 This quantity is a measure of the resistance of cloth to bending by external forces. It is related to the quality of stiffness that is appreciated when a fabric is handled; that is, the cloth having a high flexural rigidity tends to feel stiff.

3.3 Bending Length

Cube root of the ratio of the flexural rigidity (milligram-centimetres) to the weight per unit area (miligram per square centimetre) of the fabric. Bending length equals half the length of rectangular strip of fabric that will bend under its own weight to an angle of 41.5°. It is also equal to the length of a rectangular strip of materials that will bend under its own weight to an angle of 7.1°. It is expressed in centimetres.

3.3.1 This quantity is one of the factor that determines the manner in which fabric drapes. It is related to the quality of the stiffness that is appreciated by visual examination of the draped material, that is, the cloth having high bending length tends to drape stiffly.

4 SAMPLING

Sample drawn in accordance with the procedure laid down in relevant specification for the material or as agreed to between the buyer and the seller shall be representative of the lot.

5 PREPARATION OF TEST SPECIMENS

5.1 From the samples, as selected in **4.1** cut rectangular warpway and weftway test specimens of 25 mm × 200 mm size preferably with the help of a template from different portions of the sample under test. The lengthwise direction of specimens shall be parallel to the warp or weft direction for which the stiffness is to be determined. Specimens cut in each direction shall be scattered as far as possible so that no two warpway specimens contain the same set of warp yarns and no two weftway specimens contain the same set of weft yarns. Avoid selvedges (within 10 cm), end portions, creased or folded places. The specimens shall be handled as little as possible.

6 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

6.1 Prior to test, the fabrics shall be conditioned to moisture equilibrium and tested in standard atmospheric conditions of 65 ± 2 percent RH and 27 ± 2°C temperature as laid down in IS 6359 1971 'Methods for conditioning of textiles' given in Section B-1/1.

6.2 The test shall be carried out in standard atmosphere (*see* **6.1**).

7 APPARATUS

7.1 Stiffness Tester

Having the following parts:

a) *Horizontal Platform* - It shall have a minimum area of 40 mm × 200 mm and a flat smooth and low friction surface, such as polished metal. It shall be preferably equipped with spirit level for leveling.

b) *Indicator* – It shall be inclined at an angle of 41.5° below the plane of the platform surface from the edge of the platform.

c) *Scale* – It shall be of 25 mm × 200 mm weighing 10 ±2 g/cm with rough bottom surface to grip the specimen and graduated in centimetres and millimetres.

8 PROCEDURE

8.1 Place the tester on a table or bench so that horizontal platform and inclined reference line are at eye level of the operator. Adjust the platform with the help of a spirit level so that it is horizontal.

8.2 Place one of the specimens on the platform with the scale on top of it lengthwise and the zero of scale coinciding with the leading edge of the specimen. Holding the scale in the horizontal plane, start pushing the specimen and the scale slowly and steadily when the leading edges project beyond the edge of the platform. An increasing part of the specimen will over hang and start bending under its own weight. Keep an eye in such a position that the two inclined line (of the inclined plane making an angle of 41.5° with the horizontal) of the tester coincide. Stop pushing the specimen when its tip reaches the level of inclined plane. If the specimen has a tendency to twist, take a reference point at the centre of the leading edge. Do not measure the specimen which twists more than 45°. Note down the length of the overhanging portion from the scale to the nearest millimetre.

8.3 Take four readings from each specimen with each side up, first at one end and then at the other.

NOTE — A typical sketch of stiffness tester is given in Fig. 1.

8.4 Similarly, test at least 4 test specimens for each warpway and weftway.

8.5 Determine the weight per unit area of the fabric according to IS 1964:1970 'Methods for determination of weight per square metre and weight per linear metre of fabrics (*first revision*)', given in Section B-3/3 and express in terms of milligrams per square centimetre. Alternatively the weight per unit area can be determined by weighing all the warpway and weftway test specimens together after completion of stiffness test.

9 CALCULATIONS

9.1 Calculate the average of the four readings for each test specimen.

Determine the average of the values for the warpway and weftway test specimens separately.

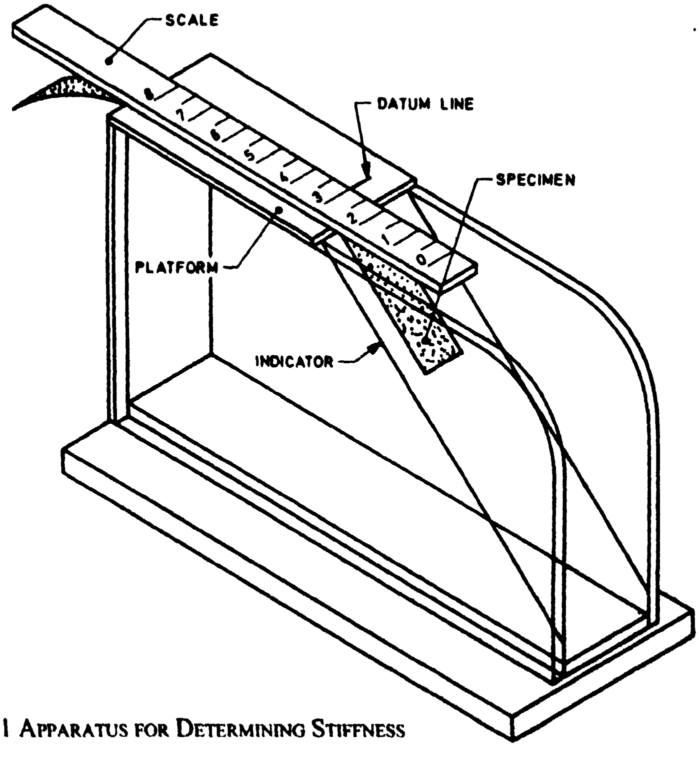


FIG. 1 APPARATUS FOR DETERMINING STIFFNESS

9.2 Determine the bending length, the flexural rigidity for warpway and weftway specimens and the overall flexural rigidity by the following formula:

a) Bending length

$$C = \frac{L}{2}\text{cm}$$

where

L = the mean length of over-hanging portion in centimetres.

b) Flexural rigidity

$$G = W \times \left(\frac{L}{2}\right)^3 \text{mg-cm}$$

where

W = weight per unit area of the fabric in milligrams per square centimetre.

c) Overall flexural rigidity

$$G_o = \sqrt{G_w \times G_f}$$

where

G_w = warpway flexural rigidity, and
G_f = weftway flexural rigidity.

10 REPORT

The report shall include the following information:

a) Type of fabric
b) Number of test specimens tested:
   1) Warpway, and
   2) Weftway.
c) Bending length:
   1) Warpway and
   2) Weftway.
d) Flexural rigidity:
   1) Warpway, and
   2) Weftway.
e) Overall flexural rigidity, if required.

DETERMINATION OF THERMAL RESISTANCE OF TEXTILE FABRICS GUARDED HOT-PLATE METHOD

(*Source* : IS 2702:1965)

The thermal resistance of a fabric is one of the important factors which influence the effectiveness of the fabric in keeping the body comfortable. This factor includes the thermal conductivity of the fabric.

1 SCOPE

1.1 It prescribes a method for determining the thermal resistance of textile fabrics.

1.2 This method is applicable to all types of textile fabrics including blankets shawls, etc, irrespective of their composition (that is irrespective of whether the fabric is made of wool, silk, nylon or a blend of two or more textile fibres) and their construction (that is, irrespective of whether the material is a woven fabric, a knitted fabric or a felted material).

2 TERMINOLOGY

2.1 Thermal Resistance

The resistance offered by the fabric to the flow of heat when its two faces are at different temperatures, as denoted by the ratio of the temperature difference to the rate of flow of heat per unit area, the flow being normal to the surfaces.

NOTE -- Since surface temperatures of fabrics are difficult to measure precisely, the temperature difference between the hot-plate on which the fabric is put during test and that of air 20 mm above the other surface of the fabric will be taken to assess the thermal resistance.

2.2 Tog

The unit of thermal resistance. This is the resistance that will maintain a difference of 10 degree between two parallel isothermal plates with a heat flux of one watt per square decimetre.

NOTES

1 By adopting this unit the thermal resistance of any fabric could be conveniently described by a range of small integers (1 to 10). For example, a light summer suiting has a thermal resistance of 1 tog and 10 togs represent the thickest clothing that could be worn.

2 Still air has a thermal resistance of 0.4 togs approximately.

3 SAMPLING

Sample to determine conformity of a lot to this standard shall be selected so as to be representative of the lot.

4 APPARATUS

4.1 The apparatus shall consist of:

a) hot-plate assembly,
b) heaters, and
c) devices for measuring the surface temperature of hot-plates.

4.1.1 *Hot-Plate Assembly*

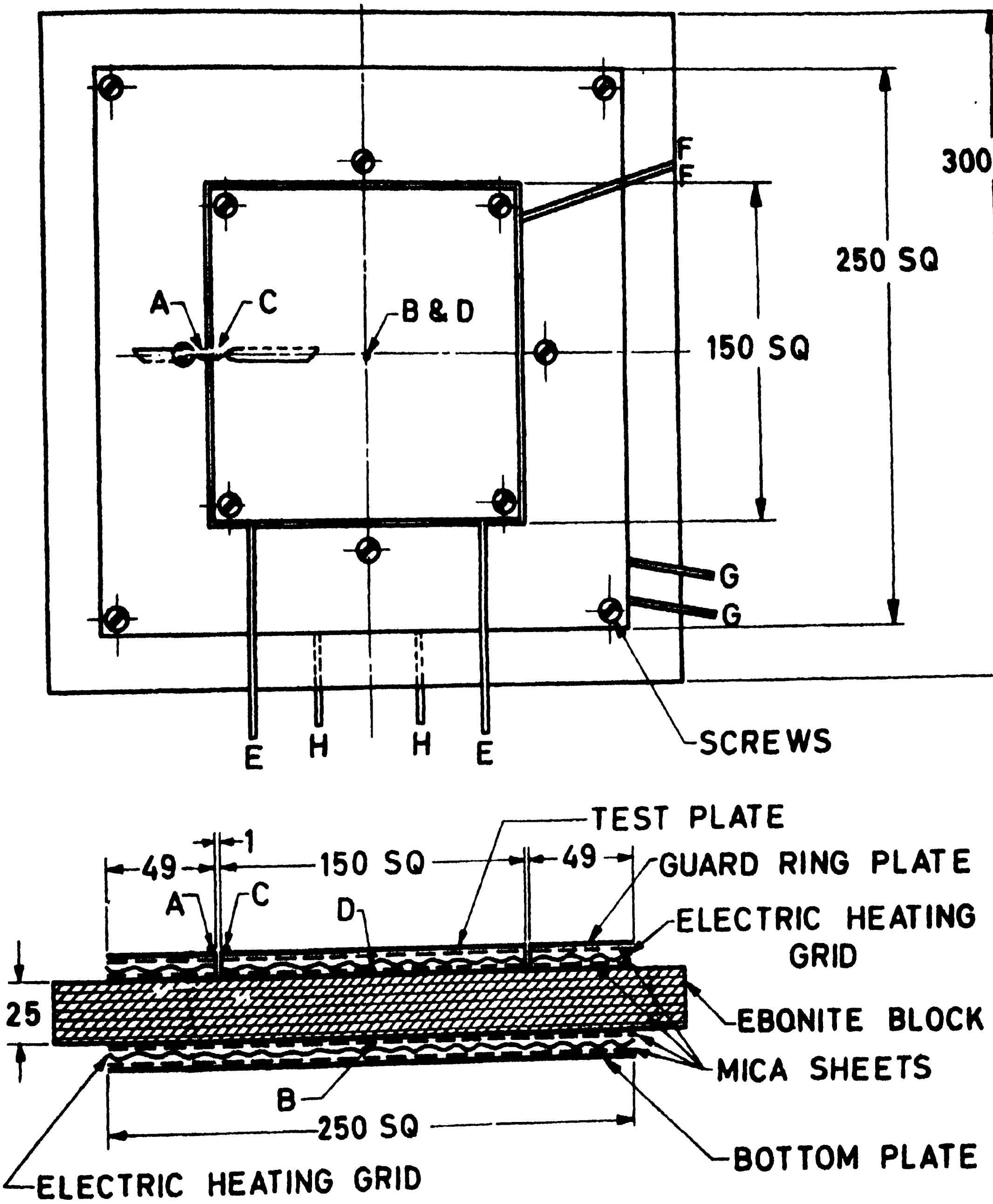
The hot-plate assembly (*see* Fig. 1) shall consist of the test plate, guard ring plate and the bottom plate which is intended to prevent a downward loss of heat from the other two plates. All the plates shall be made from thin (1.5 mm to 2 mm thick) sheets of highly conductive metal like copper. The surface of the metal shall be finished to a true plane and lacquered to give a high emissivity. Each of these shall be electrically heated and maintained at a constant temperature by separate heating grids.

4.1.1.1 The hot-plate assembly shall be housed in an air-tight wooden box one metre cube provided with:

a) thermostatic arrangement to maintain a constant temperature with an accuracy of ± 0.5°C at about 8 to 10°C below the bottom plate temperature,
b) arrangements to maintain a constant humidity within the box and to measure it,
c) arrangements to maintain the velocity of air at 1 m/s,
d) suitable means to direct the air current so as to impinge on the specimen at an angle of 45°, and
e) thermocouples suspended inside the box so that the measuring junction is exposed to the air at 20 mm above the test specimen to measure the temperature of the ambient air inside the box.

4.1.2 *Heaters*

Each of the heating grids used for maintaining the plates at constant temperature shall be provided with separate



B – Bottom-plate thermo-couple
C,D – Test-plate thermo-couples
EE – Test-plate heater-terminals
FF – Differential-couple across the test plate and guard ring plate
GG – Guard-ring plate heater terminals
HH – Bottom-plate heater terminals
A – Guard-ring plate thermo-couple
SQ – Square dimension

All dimensions in millimetres.

FIG. 1 HOT PLATE ASSEMBLY

electric circuit with a control to adjust the current and meters to measure the current and the voltage to an accuracy of ± 1 percent. The current may be alternating or direct. The heating grids shall be insulated from the plates by means of thin sheets of mica.

4.1.3 *Devices for measuring Surface Temperature*

The surface temperature of the hot-plates shall be measured by fine wire thermocouples. The difference in temperature between the test plate and the guard ring plate shall be measured by a differential thermocouple.

NOTE — Calibrated thermocouples such as copper-constantan or copper-advance may be used.

4.1.3.1 Potentiometer having high sensitivity of at least 5 microvolts shall be used for measuring thermal electromotive force and other voltages. The wattage of the central heater may be measured.

5 PREPARATION OF TEST SPECIMEN

5.1 Cut out from each piece constituting the test sample a test specimen (*see* Note) of 300 mm × 300 mm such that two adjacent sides are parallel to the direction of warp and weft respectively. Cut out at least 3 more test specimens so that the total number of test specimens is at least 4.

NOTE — In case the sample is a woven fabric cut out the test specimen from a distance of at least 150 mm away from the selvedges.

6 PROCEDURE

6.1 Switch on the electrical circuit of the three heaters and adjust the current so as to maintain the temperature of the three plates at 33°C to 36°C.

NOTES

1 All the plates are to be kept at the same temperature so that all the electrical energy supplied to the test plate is lost as heat energy only in direction normal to the fabric under test.

2 In order to simulate the actual condition of sample when in use, the temperature has been prescribed as 33°C to 36°C which is assumed as the typical human skin temperature.

6.2 Adjust the temperature of the air inside the wooden box to remain at a constant value of 25°C and the air circulating inside the box at a velocity of 1 m /s and the humidity at a constant value.

6.3 Transfer the test specimen to the test plate. If the test specimen is pre-heated (*see* Note), this transfer should be effected very quickly. By means of suitable clamps, keep the test specimen in contact with the test plate and guard ring plate at zero tension and close the wooden box.

NOTE — At low temperatures when testing takes more time pre-heating may be done, if necessary.

6.4 Read the temperature of the test plate, guard ring plate and the bottom plate at half-hour intervals until the three temperatures show identical and constant values (*see* Note) and the differential thermocouple gives zero reading. Take again at least four more readings at half-hour intervals. Note down this constant temperature (T_1). Note down the current in amperes (C) and the voltage (V) as read from the ammeter and voltmeter respectively, of the heater circuit of the test plate. By means of the thermocouple kept at 20 mm above the test specimens, measure the ambient air temperature (T_2) inside the box.

NOTE — If the difference in temperature between the successive readings does not exceed 0.1°C, the temperature shall be held to be constant.

6.5 Calculate, correct to two places of decimals, the thermal resistance in togs of the test specimen as under:

Thermal resistance, in togs, of the test specimen =

$$a \times \frac{(T_1 - T_2) \times 10}{C \times V \times 10}$$

where

a = area of the test plate in dm²;

T_1 = temperature of test plate in °C;

T_2 = temperature of ambient air inside the box in °C;

C = current, in amperes, to maintain the test plate at T_1°C; and

V = voltage required to maintain the test plate at T_1°C.

6.6 Repeat the test with the remaining test specimens and calculate the mean of the values. Report it as the thermal resistance of the fabric in the lot. Report also the relative humidity inside the box.

7 REPORT

The report shall include the following information:

a) Type of fabrics,
b) Thermal resistance togs, and
c) Relative humidity inside the base.

METHOD FOR ASSESSMENT OF FABRIC DRAPE

(*Source* : IS 8357:1977)

Drape is one of the subjective performance characteristics of fabric that contributes to asthetic appeal; it is a complex property involving bending and shearing deformations. The present method provides objective estimation of the extent to which a fabric drapes; draping quality is expressed as drape coefficient which theoretically varies between 0 and 100.

Drape measurements can be employed for study of the effects of fabric geometry, chemical processing treatments and finishes for woven and knitted fabrics, certain qualities of non-wovens like leather for apparel. Drape coefficient can also be used as an index for control of batches in production.

1 SCOPE

It prescribes a method for assessment of drape of fabrics and is applicable to all fabrics intended for end uses in which drape is important.

2 PRINCIPLE

A circular fabric specimen is sandwiched between two horizontal discs of smaller diameter, and the unsupported annular ring of fabric is allowed to hang down under the action of gravity. A planar projection of the contour of the draped specimen is recorded on a light-sensitive paper. The drape pattern obtained is cut along the outline and its area determined gravimetrically. The drape coefficient is calculated as the ratio of the projected area of the drape specimen to its theoretical maximum.

3 TERMINOLOGY

For the purpose of this test method the following definitions shall apply.

3.1 Fabric Drape

The extent to which a fabric will deform when it is allowed to hang under its own weight.

3.2 Drape Co-efficient

The area covered by the shadow of the draped specimen expressed as a percentage of the area of the annular ring of fabric.

4 APPARATUS

4.1 Drape Tester

Consisting of :

a) a pair of horizontal discs of 12.3 cm diameter between which the specimen is held; the lower disc has a central pin for positioning on a holder.
b) an actinic source of light placed directly above the centre of the discs with suitable attachment to give a parallel beam of light.
c) arrangement to place a sheet of ammonia process paper horizontally below the draped specimen (*see also* **4.3**).
d) timer and other devices to aid exposure for prescribed time.
e) an enclosed box for developing the drape pattern in ammonia vapour.

NOTE — An outling of a suitable apparatus developed by Bombay Textile Research Association, Bombay working on the above principles is given in Annex A. Mention of the name of a specific (or proprietory) instrument is not intended to promote or give preference to the use of that instrument over those not mentioned.

4.2 Circular Template

A metal template of 250 mm diameter and with a central hole for marking and cutting specimens for drape test.

4.3 Ammonia Process Paper

NOTES

1 In case ammonia process paper is not availbale, a good quality drawing paper may be used, and the outline of the drape pattern may be carefully traced by hand.

2 For better results photographic grade of ammonia paper may be used.

4.4 Balance

Capable of determining mass to the accuracy of 0.01 g.

5 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

5.1 The test specimens shall be conditioned to mositure equilibrium in standard atmosphere of 65 ± 2 percent RH and 27 ± 2°C before testing (*see* IS 6359:1971

'Method for conditioning of textiles' given in Section B-1/1)and the tests shall be carried out in the standard atmosphere.

6 PREPARATION OF TEST SPECIMENS

6.1 Marking and Cutting

Place the fabric free from creases and wrinkles on a flat horizontal surface and by means of the template (4.2) trace the outline, mark the centre of each, and cut the specimens. Ensure that the specimens represent adequately the fabric under test and exclude the areas within 5 cm of the selvedges and those with wrinkles or sharp folds.

7 PROCEDURE

7.1 Place the drape tester firmly on a level table. Switch on the light (The mercury vapour lamp when lighted attains full brightness after a few minutes.).

7.2 Remove the specimen holder from the bayonet socket and place a cut fabric specimen between the plates. Hold the stub of the specimen holder assembly and briskly move the holder with the specimen up and down ten times, each time resting on the table for a moment (This is to allow the fabric to orient itself freely and drape into natural folds.).

7.3 Place a square of ammonia process paper on the base of the instrument and lay it flat.

7.4 Insert the stub of the specimen holder (with the specimen) in the socket on the threaded bolt. Press upwards and turn counter clock-wise to lock the holder in position.

7.5 Looking along the level of the base-board, adjust the height of the drooping edge of the drape specimens, so that the lowermost edge is just above the paper without touching it.

7.6 Adjust the setting knob of the timer for the required time of exposure.

NOTE — The optimum exposure time depends on the quality of the paper used, and will have to be determined experimentally.

7.7 At the end of the exposure time, remove the ammonia process paper and place the same in the developing box containing a few millilitres of strong ammonia solution. Remove the paper when the latent is developed.

7.8 Condition the paper to moisture equilibrium in standard atmosphere. Cut out the drape pattern with a pair of scissors and determine its mass in gram correct to two decimal places.

7.9 Determine the mass per unit area of the paper used by cutting a known area of the original paper and weighing.

7.10 Reverse the specimen and obtain the drape pattern with the other surface upwards.

7.11 Number of Tests

Test at least four specimens making a total of eight measurements.

8 CALCULATIONS

8.1 Calculate the drape co-efficient for each test as under:

Drape co-efficient (F%) $= \dfrac{\dfrac{w}{W} - a}{A - a} \times 100$

where

W = mass per unit area of the paper,

w = mass of the drape pattern,

a = area of circle of 12.5 cm diameter = 122.8 cm^2,

and

A = Area of circle of 25 cm diameter = 491.1cm^2.

OR

By substituting the values of 'a' and 'A':

$$\text{Drape co-efficient} = \frac{\dfrac{w}{W} - 122.8}{368.3} \times 100$$

8.2 Calculate the arithmetic mean of all the individual test values and round it off to two significant figures.

9 REPORT

9.0 The report shall comprise the following information:

a) Type of fabric;
b) Name of the instrument used;
c) Number of specimens tested; and
d) Mean drape co-efficient.

ANNEX A

[*Clause* 4.1 *(Note)*]

OUTLINE OF A DRAPE TESTER

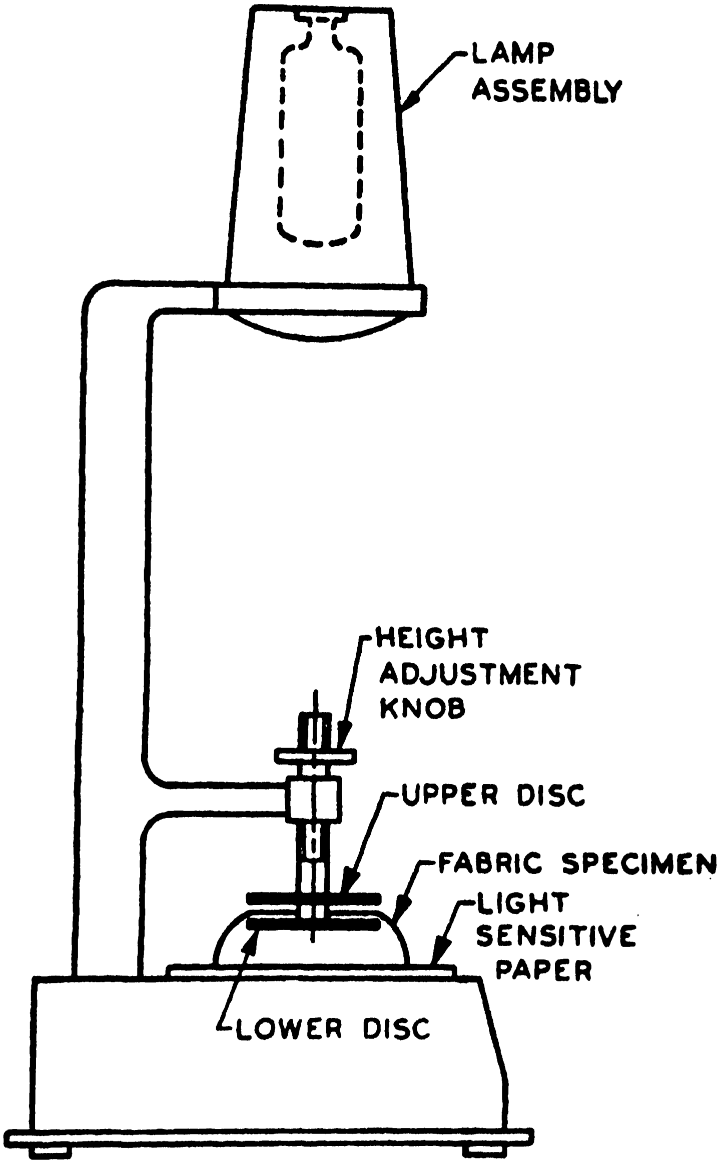


FIG. 1 ESSENTIAL FEATURES OF DRAPE TESTER

DETERMINATION OF ABRASION RESISTANCE OF TEXTILE FABRICS

(*Source* : **IS 12673:1989**)

Several factors such as bending, stretching, tearing, abrasion, laundering and cleaning contribute to the wear performance or durability of fabrics. Abrasion which is just one aspect of wear is caused by the rubbing of the component fibres and yarns of the fabric.

The nature of abrasion met within the actual use of a fabric is of different type and severity. Therefore, it is virtually impossible to imitate the abrasion exactly in any one labroatory test. In addition, the conditions of abrasion operating on different types of fabrics are so different that a single type of abrasion test to assess the relative durability of each is not feasible.

The type of abrasion test suitable for a given fabric depends on the assessment of the relative importance of factors that can be anticipated as being more involved during service (such as, rubbing or flexing).

The approach followed here is, therefore, to subject a fabric to such type of abrasion and determine whether one fabric will probably outlast in similar and specified end use. For instance, the durability of a newly developed fabric can be compared with an already accepted fabric.

Laboratory assessment of abrasion resistance of a fabric can be affected by many variable factors, namely, nature of abradant, tension on test specimens, pressure between abradant and test-specimens, direction and speed of the abradant motion, removal of lint and other debris, and judgement of operator when a visual end point is used. Variation in these abrasion conditions can easily cause a larger deviation in test results than that due to the difference among samples, thus invalidating the results of an entire test. Hence, the abrasion resistance results obtained by different operators and in different laboratories may show a high degree of variability and the precision of this method is uncertain. Considerable caution is, therefore, required in interpreting the results of abrasion tests which cannot be relied upon for comparing fabrics of widely different fibre compositions or construction.

1 SCOPE

1.1 It prescribes methods for the determination of resistance of textile fabrics to plane abrasion (flat abrasion) and flex abrasion.

1.2 Except for floor covering fabrics, the methods prescribed are applicable to all textile fabrics, irrespective of their composition (that is whether the fabric is made of cotton, wool, silk, jute or man-made fibres or a blend of two or more such fibres) and history (that is, the manufacturing processes involved and the finishing treatments).

1.3 In the case of narrow fabrics, only flex abrasion resistance shall be determined.

2 TERMINOLOGY

For the purpose of this test method the following definitions shall apply.

2.1 Abrasion

The wearing away of any part of a material by rubbing against another surface.

2.2 Plane Abrasion

The abrasion of the material from flat area.

2.3 Flex Abrasion

Rubbing accompanied by flexing and bending.

2.4 Edge Abrasion

Abrasion similar to the one occurring at collars and folds.

3 SAMPLING

Sample from the lot shall be drawn so as to be representative of the lot. Sample drawn in accordance with the relevant material specification or as agreed to between the buyer and the seller shall be held to be representative of the lot. In the absence of above, the procedure given in IS 3919:1966 (*see* Section A-1/2) may be followed.

4 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

4.1 Prior to test, the fabric shall be conditioned to moisture equilibrium from the dry side, in the standard atmosphere of 65 ± 2 percent relative humidity and 27 ± 2°C temperature as prescribed in IS 6359:1971 (*see* Section B-1/1).

4.2 The test shall be carried out under standard atmospheric conditions.

5 CHOICE OF METHOD

Any one of the methods may be used for determination of abrasion resistance of fabric depending upon the material specification or agreement between the parties, about the type of the instruments, facilities available and character of testing desired, such as, plane abrasion or flex abrasion.

6 DETERMINATION OF PLANE ABRASION RESISTANCE

6.1 General

Although plane abrasion of fabric surface does not necessarily cover all aspects of strains which are important in determining service life, there are occasions when such a test gives useful information. Plane abrasion resistance shall be determined using one of the two commercially available testers (*see* Annex A and B) by Method 1 and 2.

6.2 Method 1

6.2.1 *Principle*

Circular specimens of fabric are abraded under known pressure on an apparatus giving a motion which is the resultant of two simple harmonic motions at right angles to each other. The resistance to abrasion is estimated by breakage of threads or by loss in mass of the specimens.

6.2.2 *Apparatus*

The abrasion tester is described in Annex A.

NOTE — The apparatus specified in this test was designed to give a controlled amount of abrasion between fabric surfaces at comparatively low pressure in continuously changing directions.

6.2.3 *Test Specimen Preparation*

Cut or punch four circular specimens of 38 mm diameter for the breakage method of assessment and eight specimens for the loss in mass method of assessment.

6.2.4 *Test Procedure*

6.2.4.1 Mount test specimen on a 38 mm diameter circular piece of foam placed in the specimen holder. Keep the specimen under tension by pressing the holder against the brass plate provided on the base of the apparatus and screw it up tightly.

6.2.4.2 Mount a new piece of abradant on each of the four tables with a piece of felt, as specified, beneath the abradant. Keep the abradant under tension by placing a weight on its surface before tightening up the retaining frame. Replace the abradant at the start of each test and after 50 000 rubs, if the test is continued beyond this number.

6.2.4.3 Clamp the specimen holders on the moving plate under the desired load and switch on the machine.

NOTE — Normally a total load of 125 g/cm^2 is used but a lower load of 30 g/cm^2 may be used if agreed to between the buyer and the seller.

6.2.5 *Choosing of the End-Point*

Estimate the resistance to abrasion either by abrading till two threads break or by loss in mass of the specimens, as has been agreed to between the buyer and the seller.

6.2.5.2 *Breakage of threads*

Continue abrading the specimens until two threads are broken, rounding each reading to the nearest 1 000 rubs. Record the number of rubs required before breakage occurs. In some cases, removal of surface nap or other state is a more appropriate end-point and this should be used, if agreed to between the buyer and the seller.

6.2.5.3 *Average rate of loss in mass*

Abrade two specimens to end-point as described in 7.1.5.2 to get approximate idea of abrasion resistance of the sample and further pairs of specimens to three intermediate stages of approximately 25, 50 and 75 percent of the estimated abrasion resistance value choosing the convenient numbers of rubs from the range 100, 250, 500, 1 000, 1 500, 2 000, 2 500, 5 000, 7 500, 10 000 and 15 000. Recondition the specimens and weigh to the nearest 1 mg.

6.2.5.4 Plot a graph between the loss in mass and the number of rubs. If the points lie in straight line, draw a line and determine the average rate of loss in mass in mg/1 000 rub. If the points lie in curve, draw a curve and read off the loss in mass at three convenient points chosen from the suitable range.

6.2.6 *Report*

The report shall include the following information:

a) Description of the material tested;
b) Type of abradant used;
c) Pressure used and the criterion for judging the end point;
d) Average of rubs to specified end points; and
e) If applicable, the average rate of loss in mass or the loss in mass at three stages, taken from a smooth curve through the points.

6.3 Method 2

6.3.1 *Principle*

Abrasion resistance of a specimen held in a fixed position and supported by an inflated rubber diaphragm is determined by rubbing either unidirectionally or multidirectionally against a standard abradant.

6.3.2 *Apparatus*

The abrasion tester is described in Annex B.

6.3.3 *Test Specimen Preparation*

Cut five circular test specimens of 112 mm in diameter, taking care to avoid specimens from areas containing the same wales or courses in knitted fabrics or the same warp and weft yarns in wove fabrics.

6.3.4 *Procedure*

6.3.4.1 Place the specimen over the rubber diaphragm in a smooth condition and clamp the specimen in place without distorting it.

6.3.4.2 Place the abrasive paper or other abradant on the abradant plate under sufficient tension to be held smooth and in such a position that the contact pin, reaching through a hole in the abradant, is even with the surface of the abradant.

NOTES

1 In the absence of any specific material specifications zero emery polishing paper should be used as the abradant.

2 If the continuous changing abradant head is used, it should be noted that, although the weight of the head is counter balanced, the balance changes during use as the paper passes from the back roll to the front roll.

6.3.4.3 Set the air pressure under the diaphragm and load on the abradant plate. In the absence of any specific material specifications, the air pressure should be 0.3 Kg/cm^2 (4 p.s.i.) and the load on the abradant should be 454 g. Ensure that the air pressure control and contact between the inflated specimen and loaded abradant is in a state of equilibrium before abrasion is started. To ensure consistent inflation of the diaphragm, inflate to a higher air pressure (25 percent) and then reduce to testing pressure.

6.3.4.4 If unidirectional abrasion is desired, disengage the rotation mechanism of the specimen clamp and bring the specimen into the desired direction by turning and setting the clamp after the diaphragm has been inflated.

6.3.4.5 In the event that multidirectional abrasion is required, or if no specific indication as to the abrasion direction is given in the fabric specification, engage the rotation mechanism of the specimen clamp.

6.3.4.6 Remove pills of matted fibres interfering with proper contact between specimens and abradant during the test if they cause a marked vibration of the abradant plate.

6.3.4.7 If the specimen slips in the clamp or the air pressure does not remain constant during the test or an anomalous wear pattern is obtained, discard such individual measurements and test an additional specimen.

6.3.5 *Choosing of the End-Point*

6.3.5.1 *Breakage of threads*

Abrade the specimen until all fibres in the centre of the abraded area are worn off so that the diaphragm and the abradant head come into contact and the instrument automatically stops.

6.3.5.2 *Removing a predetermined thickness of the material*

Abrade the specimen using the electrical depth micrometer to determine the automatic end-point for removing a predetermined thickness of the material from the specimen as agreed to between the buyer and the seller.

NOTES

1 For testing coated fabrics as well as plastic and rubber sheeting which are considered to be worn out, when they become permeable to air, a diphragm with a hole in the centre is used As soon as sufficient surface material has been worn off from the specimen to permit air leakage the inflated specimen collapses and the machine is automatically stopped.

2 Stiff materials and materials with irregular contours such as fibre-glass fabrics, stiff pile fabrics, etc, are tested by assembling specimens with two diaphragms, the outer diaphragms with a large hole enabling contact between the specimen and the abradant plate.

3 Unless the continuous changing abrasion head is used, it is recommended that the abradant paper be changed after every 300 cycles.

6.3.6 *Report*

The report shall include the following information:

a) Type of abradant,
b) Type of abrasion (unidirectional or multidirectional), and
c) Number of cycles to reach the end point as determined by electrical contact.

7 DETERMINATION OF FLEX ABRASION RESISTANCE

7.1 Principle

A specimen of the fabric is subjected to unidirectional reciprocal folding and rubbing over a bar having specified characteristics under known conditions of pressure and tension to evaluate the flex abrasion resistance.

7.2 Description of Apparatus

A tester as specified in the Annex C shall be used.

7.3 Test Specimen Preparation

7.3.1 Unless and otherwise specified by a material specification or by an agreement between the purchaser and the seller, five test specimens shall be tested.

7.3.2 Cut the test specimen 200 mm long and of 32 or 38 mm width depending on whether the number of yarns/dm of the specimens is below or above 200. Ravel the specimen to 25 mm in width by removing from each side approximately the same number of yarns. Do not take two specimens for the warp test from the same warp ends or any two specimens for the weft test from the same picks. Take weft specimens at sufficiently wide intervals, whenever possible, to ensure the inclusion of yarn from different cops.

7.4 Procedure

7.4.1 After positioning the bar by means of the yoke holder, place the specimen between the pressure (upper) plate and the reciprocating (lower) plate of the apparatus and locate centrally. With the specified folding bar of folding blade inserted, after being clamped and loaded by removal of the yoke holder, distribute the tension exerted by the bar or blade uniformly over the width of the specimen and align the long dimension both above and below the bar parallel to the direction of the reciprocating motion. Position the specimen with the fold at the centre (midpoint) of the upper plate, and the reciprocating plate at the rear of its stroke when the specimen is clamped.

7.4.2 Load the pressure plate and folding bar or blade as required by the material specification. In the absence of the material specification, it is recommended that bar load sufficient to produce rupture in excess of at least 100 cycles and preferably 300 cycles be used, in combination with the lowest head load (pressure) (*see* Note) sufficient to prevent vibration of the upper plate at the start of the test. A ratio of bar to head loads of 4:1 is recommended.

NOTE — A low level of load is required to prevent ripping of the fabric during testing. This ripping is caused by a high degree of friction between the fabric and the bar when abnormally high loads are applied and results in insufficient relative motion between the bar and the fabric specimen under test.

7.4.3 Check the bar alignment after the first 25 cycles by noting whether the bar has shifted laterally to either side of its normal rest position. If such shifting occurs, discard the specimen and make the proper adjustment.

7.4.4 Remove the pills of matted fibre debris interfering with proper contact between the specimen and the folding bar or folding blade during the test if they cause a marked vibration of the pressure plate or other wise interfere with proper abrasion. The pills should preferably be removed by careful clipping. Do not attempt to correct the vibration of the pressure plate due to pilling by applying additional load. Check the position of the specimen after additional cycles to ensure that the removal of pills has not altered the bar alignment.

7.4.5 If the specimen slips in the clamps or tension and pressure upon the folded specimen do not remain constant during the text, or an anomalous wear pattern is obtained, disregard such individual measurements and test an additional specimen.

7.4.6 Before the new blade is used, rinse it with as degreasing agent. Repeat this after every specimen is run. Also wipe the pressure plate with tissue saturated in the solvent.

7.4.7 Determine the end point by one of the following methods as given in **8.4.8** or **8.4.9**.

7.4.8 *Failure*

Abrade the specimen until ruptured.

7.4.9 *Percentage Loss in Breaking Load*

Abrade the specimen a specified number of cycles and determine the breaking load using ravelled strip or cut strip procedure. The abraded area of the specimen should be placed midway between the clamps of the machine. Compare this breaking load with the breaking load determined under the same conditions on an unabraded portion of the same sample. Calculate the loss in breaking load and report to the nearest 10 percent using the formula:

$$\text{Percentage loss in breaking load} = \frac{100(A - B)}{A}$$

where

A = breaking load before abrasion, and
B = breaking load after abrasion.

7.5 Report

The report shall include the following information:

a) Abradant used, bar or blade;

b) Average number of cycles required to rupture the specimen, reported as follows:

Total Number of Cycles	*Report to the Nearest Cycle*
Below 200	10
200 to 999	25
1 000 to 4 999	50
5 000 and above	100

c) Average percentage loss of breaking strength after abrasion for one or more specified number of cycles; and

d) Tension and pressure used.

ANNEX A

(*Clauses* 6.1 and 6.2.2)

PLANE ABRASION TESTER

A-1 DESCRIPTION OF APPARATUS

A-1.1 The abrasion tester is shown in Fig. 1 and 2.

A-1.2 *P* is the brass plate resting on three supports *A*, *B* and *C*. Each support consists of a single ball bearing, about 16 mm in diameter, moving freely in a brass cup. There is a machined steel wearing plate in each cup and all three are co-planar By this means the plate is enabled to glide about easily in the approximately horizontal plane determined by the three point supports. On the

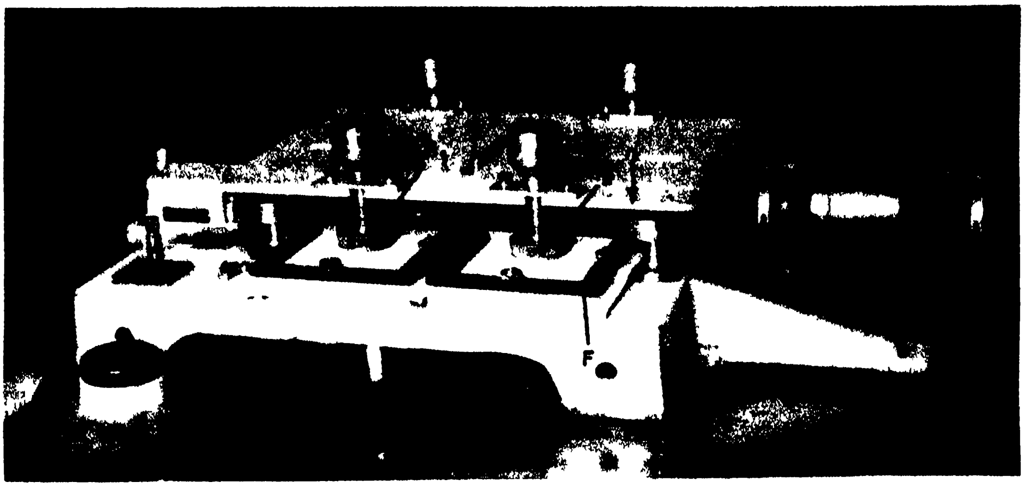


FIG. 1 PLANE ABRASION TESTER (WITH BRASS PLATE)

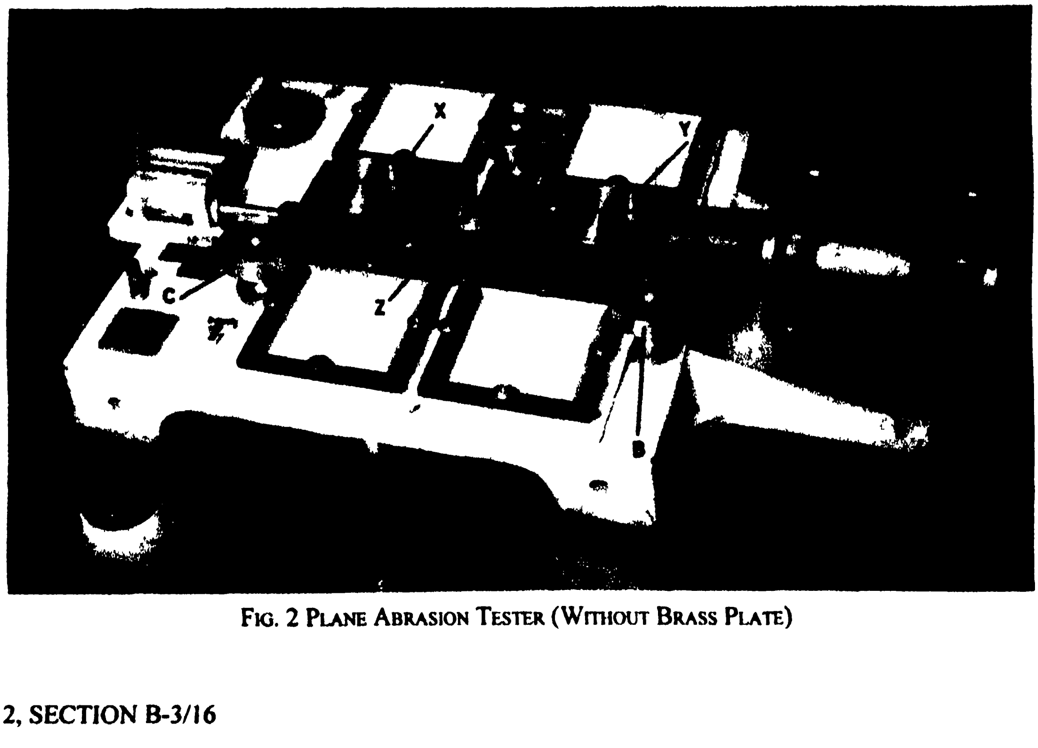


FIG. 2 PLANE ABRASION TESTER (WITHOUT BRASS PLATE)

lower side of the plate are three steel plates machined flat and co-planar which provide upper wearing surface for the ball bearings. The plate is given the resultant movement of two simple harmonic motions at right angles in such a way that every point on it traces out a path known as Lissajous figure (*see* Fig.3). This is the result of the relative motion of two outer pegs (*X* and *Y*) which are synchronized and driven at the same speed of 47.5 ± 2 rev per min while the inner peg(s) rotate(s) at a slightly lesser speed than the outer pegs with the speeds in the ratio of 30:32. The total stroke of outer pegs as well as inner pegs is 60.5 mm.

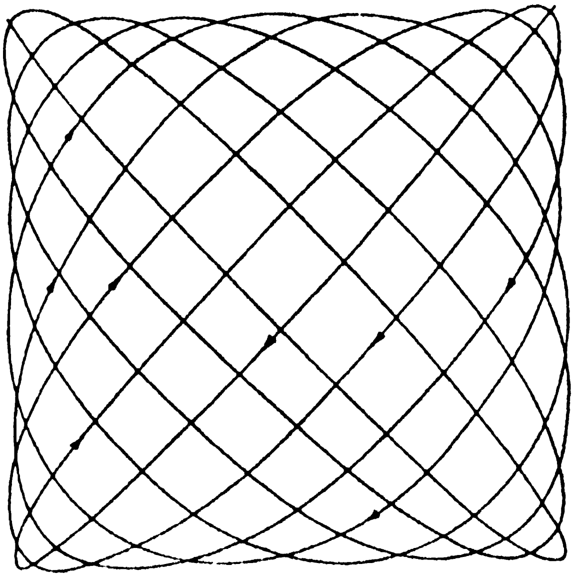


FIG. 3 LISSAJOUS FIGURE, TRACED BY PLATE (PLANE ABRASION TESTER)

A-1.3 There are recesses on two sides of the plate into which the four specimen holders (H_1, H_2, H_3 and H_4) can be fitted. Each of the specimen holder rests upon one of the four small abrading tables whose surfaces are also flat and parallel to the plane in which the plate glides. These have the freedom of movement in vertical plane but must take part in the horizontal movement of the plate. The cloth specimens in the holders are rubbed on one of the surface of the abrading table, the path of each being the Lissajous figure.

A-2 BACKING FOR SPECIMENS

A-2.1 Four circular pieces (38 mm diameter) of polyurethane foam approximately 3 mm thick and of density approximately 0.04 g/cm³ are used for backing the specimens. These are renewed when they become worn or soiled with use.

A-3 CLOTH SPECIMEN HOLDER

A-3.1 Each specimen holder consists of three parts, *A*, *B* and *C* (Fig. 4). *A* is a ring into which the cloth disc *D*, 38 mm in diameter, fits exactly. The working area of specimen holder is 6.45 cm². *B* is a kind of circular plunger which is put in on top of the cloth and *C* is screwed down over the outside of *A*. It then squeezes the plunger against the rim of *A*, gripping the cloth and as the plunger *B* protrudes slightly through *A*, the cloth is tensioned. In order to obtain a satisfactory tension the specimens are mounted by pressing the holder down against the flat surface of the brass plate provided in the base of the apparatus. A loaded specimen holder is shown in Fig. 5. With this device, the specimens may be removed at any stage of abrasion testing and weighed. They can easily be put back into the holders for further rubbing exactly the same portion of the cloth being exposed.

A-3.2 The machine makes about 3 000 rubs/h (one rub being a complete revolution of each cloth holder) and is fitted with a revolution counter and switch to stop the machine after a predetermined number of rubs.

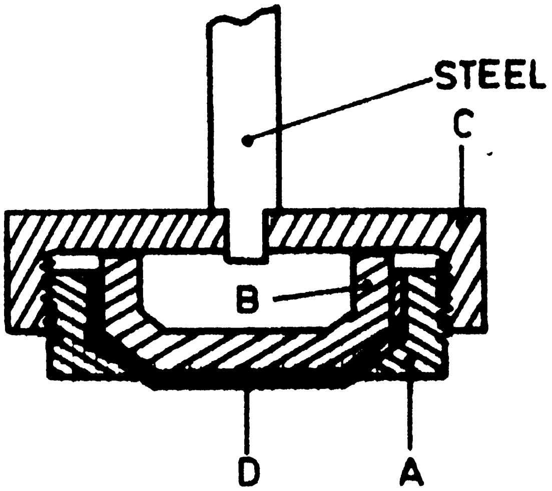


FIG. 4 CLOTH SPECIMEN HOLDER (PLANE ABRASION TESTER)

A-4 ABRADING TABLE

A-4.1 There are four square abrasion tables, one for each specimen holder. They are made of cast iron and machined flat. The surface against which the 38 mm disc is to be rubbed shall be the abrasive fabric specimen or zero emery polishing paper as has been agreed to between the buyer and the seller.

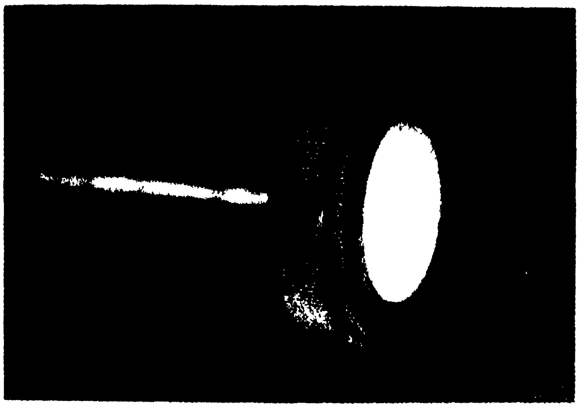


FIG. 5 LOADED SPECIMEN HOLDER (PLANE ABRASION TESTER)

A-4.2 The load on cloth specimens is adjusted to be in the range of 30g/cm^2 to 125 g/cm^2 by adding suitable weights to the top of the peg which projects through the plate.

A-4.3 The abrasive is normally mounted on the square abrasion tables of the machine over a piece of woven felt of mass 575 g/cm^2 to 675 g/m^2 and approximately 1.3 mm thick which need not be renewed until soiled or damaged.

A-4.4 The standard abrasive fabric of 125 mm^2 is laid on a abrasion table with a piece of felt as specified beneath the abradant. Place a heavy weight with a flat smooth surface on it. Then gently pull apart the opposite edges of the cloth to remove any creases. The weight holds the abrasive fabric firmly whilst a square retaining frame *F* in Fig. 1 is put over the edges of the tightened fabric. Remove the weight and the cloth will be found to be firmly covering the table, as in Fig. 2. A series of serrations on the lower side of the brass frame-work prevents the felt and fabric from slipping and working loose.

A-4.5 It has been found by experience that any difference in tension, either in specimen holder or abrading cloth, are not sufficiently large to affect the results to any appreciable extent provided that the setting is done correctly, as described above.

A-5 METHOD OF RUBBING

A-5.1 When the machine is running, the discs are rubbed over the surface on the abrading table, following the path shown in Fig. 3. At one stage, the path followed is the arc of a circle but this gradually changes and progressively alters through a series of narrowing portions of ellipses until the motion is in a striaight line along the diagonal of the figure. As the motion continues, it develops, again through the same portions of ellipses (which are, however, not described in the opposite direction) until the circular motion is again produced. This cycle or operations is repeated for as long as desired.

A-5.2 This type of motion has the advantage that the pattern under examination is rubbed in all the directions not merely warp or weft way. The motion is continually altering so that the fibres of the cloth are continually being flexed in all directions and not merely in one direction.

ANNEX B

(*Clauses* 6.1 *and* 6.3.2)

PLANE ABRASION TESTER

B-1 DESCRIPTION OF APPARATUS

The plane abrasion tester shown in Fig. 6 consists of the following parts

B-1.1 Surface Abrasion Head

The specimen is mounted in a circular clamp over a rubber diaphragm by means of a clamping ring and a tightening collar. The circular opening of the clamping ring is 94 0 mm ± 1 3 mm in diameter and that of the collar 95.3 mm or more. The height from the surface of the clamped in specimen to the upper edge of the tightening collar shall not exceed 9.5 mm. The clamping area of the body of the clamp and the ring should have gripping surfaces to prevent slipping of the specimen and leakage of air presure during the test. Means should be provided for applying air pressure to the body of the clamp so that the pressure under the diaphragm can be controlled between 0 and 0 4 kgf/cm^2 with an accuracy of ± 5 percent.

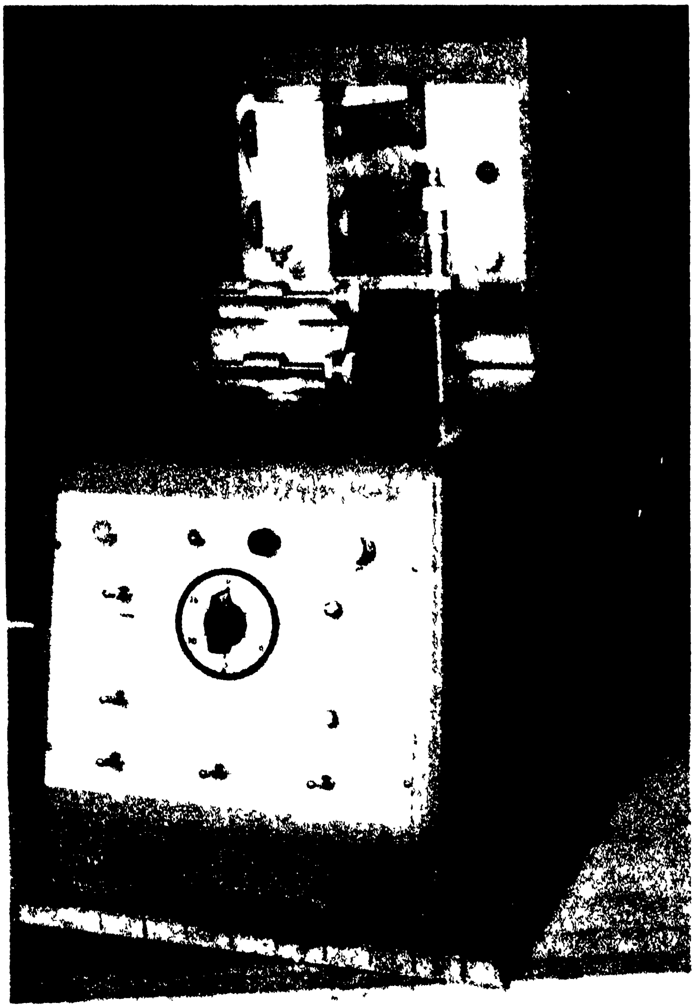


FIG. 6 PLANE ABRASION TESTTR

B-1.2 Diaphragm

The rubber diaphragm should be 1.40 mm ± 0.25 mm in thickness. A metallic contact pin 3.2 mm in diameter is sealed into the centre of the diaphragm flush with the diaphragm surface. Provision should be made for a flexible electrical connection from this contact pin to the ground of the machine. The strain distribution on the diaphragm must be uniform so that when inflated without the specimen, it assumes the shape of a sphere.

B-1.3 Driving Mechanism

The design of the driving mechanism is such that the circular clamp makes a reciprocal motion of 115 ± 15 double strokes per minute of 25 mm stroke length. Provision should be made for the rotation of the clamp in addition to the reciprocating motion so that one revolution can be completed in not less than 50 and not more than 100 double strokes.

B-1.4 Balance Head and Abradant Plate

B-1.4.1 The abradant is mounted upon a plate, which is rigidly supported by double-lever parallelogram to provide for free movement in a direction perpendicular to the plane of the reciprocating specimen-clamp. The abradant plate assembly should be well balanced to maint ain a vertical pressure equivalent to a mass of 0 to 2 270 g dead weights. Provision should be made to mount different abradants, such as, abrasive paper, fabrics, etc, on this plate, and to stretch them into an even position. An electrically insulated contact pin, adjustable to the thickness of the abradant is mounted into this plate on the length axis at one of the turning points of the centre of the clamp.

B-1.4.2 The inflated diaphragm tester can also be equipped with a continuous changing abradant head which is available from the machine manufacturer.

B-1.5 Machine Stopping Mechanism

Contact between the adjustable pin on the lower side of the abradant plate and the contact pin inserted into the centre of the diaphragm closes a low voltage circuit and stops the machine.

B-1.6 Indicator

Means should be provided for indicating the diaphragm pressure and the number of abrasion cycles (1 cycle = 1 double stroke).

ANNEX C

(*Clause* 7.2)

FLEX ABRASION TESTER

C-1 DESCRIPTION OF APPARATUS

The flex abrasion tester has following essential parts.

C-1.1 Balance Head and Flex Block Assembly

The assembly should be of two parallel, smooth plates, one of which makes a reciprocating motion of 115 ± 15 double strokes per minute, of 25 mm stroke-length. The other plate is rigidly supported by a double lever assembly to provide free movement in a direction perpendicular to the plate of the reciprocating plate. This plate is stationary during the test and must be well balanced so that a vertical load can be maintained by means of dead weights. The plates are equipped with clamps to permit the specimen, after it has been folded around the bar, to be aligned with its long dimension parallel to the axis of the reciprocal motion and equidistant from the edges of the plates. The clamps have gripping surfaces adequate to prevent slipping of the specimen during the test.

C-1.2 Flexing Bar Blade

C-1.2.1 A bar or blade is fixed depending on the specification. Flex bars with the tester have been standardized.

C-1.2.2 The flex bars should be of 1.6 mm ± 0.4 mm by 11.2 mm ± 1.6 mm cross section. It should be made of tool steel tipped with an edge of cemented carbide or other highly wear resistant material. The top, bottom and the edge of the bar which will be in contact with the specimen, should be finally finished by grinding and polishing, which levels off the microscopic projections without breaking the edges of the bar.

C-1.2.3 The folding blade should be made of tool steel 0.3 mm ± 0.13 mm by 25.4 mm ± 1.6 mm in cross section, having radius of curvature of 0.13 mm ± 0.02 mm and well polished. The bar and blade should be of such length to properly fit the yoke (tension device) employed.

C-1.2.4 Before a new unstandardized bar or blade is used for testing, it should be placed in the tester and receive to at least 20 000 cycles of abrasion using a 64-mm fabric strip under a tension of 2 270 g. A plied yarn grey cotton duck, weighing from 400 g/m² to 500 g/m² is a suitable fabric strip for this purpose. The bar or blade should then be standardized by comparing its abrasion level to that of a master standard bar or blade reserved for standardization purposes only. This comparison should be carried out on a fabric with highly uniform abrasion resistance, preferably a plain weave fabric. Where the abrasion level of the bar or blade differs by more than ± 10 percent from the level of the master standard bar or blade, the bar or blade should be reground or otherwise reworked until its abrasion level is within ± 10 percent of that of the master standard.

C-1.2.5 The testing bar should be restandardized on a regular schedule either weekly or monthly depending upon the amount of use of the given testing bar. Where the abrasion level of the bar or blade differs by more than ±10 percent from the level of the master standard bar or blade, the bar or blade should be reground or otherwise reworked until the abrasion level is within ±10 percent of that of the master standard bar or blade. The same fabric should be used for restandardization as was used for initial standardization. A standardized fabric is available from the equipment manufacturer.

C-1.3 Tension Device (Yoke)

A means for applying force to the folding bar or blade, with the force acting parallel to the surface of the two plates and perpendicular to the fold of the specimen to produce a tension evenly distributed across the fold of the specimen. The bar or blade should be prevented from tilting or rotating around its principal axis by providing means for rigidly clamping the bar to the yoke. The bar yoke used for applying tension to the bar must be sufficiently rigid to prevent its distortion, with consequent impairment of bar position, during handling and specimen loading.

C-1.4 Yoke-Positioning Device

Means should be provided to position the bar and yoke properly while loading the specimen, in order to maintain the proper bar alignment and to remove the positioning device from contact with the yoke after the specimen has been loaded and before the start of the test. Proper bar alignment is a critical factor in this test and is regulated by the length of the cables attaching the yoke to the loading platform. The proper alignment should be checked by abrading a strip of fabric and noting whether the bar shifts laterally to either side of normal rest position during the course of abrasion. Such shifting is indicative of improper bar alignment and should be adjusted by shortening or lengthening the proper cable until the shifting is no longer observed. After the proper cable length has been achieved, the cables should be clamped securely by means of locknuts to prevent subsequent change in length.

C-1.5 Machine Stopping Mechanism

A microswitch actuated by the weight rack stops the machine when the test specimen ruptures.

C-1.6 Indicator

Means are provided for indicating the number of cycle (1 cycle = 1 double stroke).

DETERMINATION OF PILE HEIGHT OF HAND-MADE CARPETS AND HANDLOOM PILE FABRICS

[*Source* : **IS 7877 (Part 4) : 1976]**

1 SCOPE

1.1 It prescribes a method for determination of the pile height, that is, tuft leg length above woven ground.

1.1.1 The tuft leg length above woven ground is the same as pile height when the pile is in the vertical position. Generally, the hand-knotted carpets have unidirectional pile, that is, the tufts lie at an angle to the ground opposite to the direction in which weaving has been proceeded. If the tufts are not measured in vertical position, the observations may not give correct results about the pile height rather it would give the measurement of pile thickness.

2 TERMINOLOGY

For the purpose of this test method, the pile height (tuft leg length) shall mean the length of pile from the point where it emerges from the woven ground to its free extremity.

3 PRINCIPLE

The pile height is found by inserting in the pile, at right angles to the woven ground, flat metal gauges of known height and determining which gauge corresponds to the pile height.

4 APPARATUS

Gauges made of flat metal strips of shape as shown in Fig. 1, available in intervals of 1 mm shall be used.

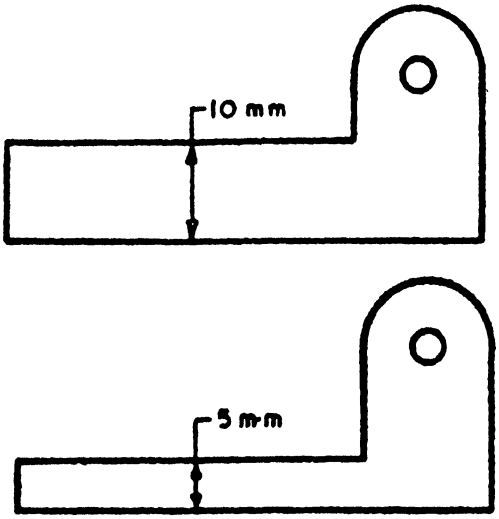


FIG. 1 GAUGES

5 PROCEDURE

5.1 Insert a gauge between two rows of pile (tuft legs) ensuring that the firm contact is made with the woven ground. Select for measurement the row of pile lying adjacent to the gauge but towards the end of the carpet last woven. Stroke the pile into vertical position besides the gauge thus giving necessary support to the pile to keep them into vertical position. By successively using different gauges, select the gauge that corresponds to the pile height. Check that this is the nearest gauge by inserting in the same position gauges a unit higher and lower than selected. Determine the pile height to the nearest millimetre.

5.2 If the handloom pile fabric due to its design, contains pile of different heights, determine the pile height at all level portions.

5.3 Repeat the measurement in the different areas of carpet.

6 REPORT

6.1 Calculate the average pile height and report the same to the nearest millimetre.

DETERMINATION OF TERRY RATIO OF TOWELLING FABRICS

(*Source* : IS 7056:1989)

1 SCOPE

It provides a method for determination of terry ratio of towelling fabrics.

2 TERMINOLOGY

For the purpose of this test method following definition shall apply.

2.1 Terry Ratio

Ratio of straightened length of terry warp threads to the mean straightened length of the ground warp threads.

3 SAMPLING

Sample taken from the lot shall be drawn so as to be representative of the lot. Sample drawn in accordance with the relevant material specification or as agreed to between the buyer and the seller shall be representative of the lot.

4 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

4.1 Prior to evaluation, the fabric pieces shall be conditioned to moisture equilibrium in the standard atmosphere of 65 ± 2 percent relative humidity and 27 ± 2°C temperature from dry side (*see* section B-1/1).

4.2 Testing shall be caried out in standard atmsophere (*see* **4.1**).

5 PROCEDURE

Cut out a 10 cm × 10 cm specimen from the fabric and condition the specimen in the standard atmosphere for testing. Remove warp threads each from the specimen of ground warp and of terry warp. Determine the mean straightened length of each group of 10 threads.

6 CALCULATION

Express the terry ratio as the ratio of the mean straightened length of the terry warp threads to the mean straightened length of the ground warp threads.

DETERMINATION OF WEFT DISTORTION OF JUTE CARPET BACKING FABRIC

[*Source* : **IS 4900 (Part 1):1984**]

Weft distortion in jute carpet backing may result in distortion of the pattern of the pile surface tufted into it.

1 SCOPE

It prescribes measurement of weft distortion (bow, bias, combined bow and bias and weft fall-off) in jute carpet backing fabric. It is applicable to all woven jute backing fabrics.

2 SUMMARY OF METHOD

Weft distortion is classified into four types: bows, bias, combined bow and skewness, and weft fall-off. There are two conditions of measurement (a) unrolling a portion of the roll, laying it flat without tension on a horizontal surface and making measurements, or (b) by measurement on the roll at the back of the rolling machine. This method is most suitable for the backing manufacturer.

A reference line perpendicular to the selvedges is drawn on the fabric. The distortion of a weft yarn is measured in relation to the reference line.

3 CONDITIONING

The fabric need not be conditioned or pre-conditioned for measurement of filling distortion.

4 APPARATUS

4.1 Racks and mandrels for unwinding the roll of fabric.

4.2 Flat surface at least 3 m (3 yd) long, and at least 150 mm (6 in) wider than the fabric to be measured.

4.3 Measuring Tape or Line

Long enough so that a perpendicular can be droped from a point on one selvedge to the opposite point (plump lines).

5 PROCEDURE

5.1 Measurement on a Flat Surface

5.1.1 Mount the roll to be measured on a mandrel and racks. Rotate the roll without pulling on the fabric. Gently lay out 3 m (3 yd) ~~of cloth~~ on a smooth horizontal surface without tension in any direction.

5.1.2 Trace one weft thread across the full width using a soft pencil or other suitable marker.

5.1.3 Measure bow by drawing a line *AC* (*See* Fig. 1 A) between the points of intersection of the marked filling thread and the selvedges. This line must be perpendicular to each selvedge. Assume bow of a pick corresponds to the curved line *ABC* of Fig. 1 A. Point *B* is the greatest distance of filling pick *ABC* from the line *AC*. Draw a perpendicular from point *B* to the line *AC* interesting it at *D*. Measure the distance *BD* to the nearest 2.5 mm (0.1 in).

5.1.4 Measure bias by tracing the position of one pick as directed in **5.1.2**. Assume that this position corresponds to the line *AC* in Fig. 1B. Draw a line perpendicular to the selvedge across the fabric from the point *C*, where the marked pick meets one selvedge, meeting the other shown in Fig. 1B, to the nearest 2.5 mm (0.1 in).

5.1.5 Measure combined bow and bias by tracing the position of one pick as directed in **5.1.2**. Assume that this position corresponds to the line *ABC* in Fig. 1C. At *C*, where the pick meets the selvedge, draw a perpendicular across the fabric meeting the opposite selvedge at point *D*. Point *B* is the greatest distance of the pick *ABC* from the line *DC*. Draw a perpendicular from point *B* to the line *DC*. Measure the distance *BE* between point *B* and the intersection *E*, of the perpendicular and line *DC* to the nearest 2.5 mm (0.1 in).

5.1.6 Measure weft fall-off on a selected filling yarn *AC* (*see* Fig. 1D). Draw a reference line (the reference line may be drawn using a chalked string) perpendicular to the selvedges. At a point *B* on the selected weft yarn, draw a perpendicular to the reference line. Measure the distance along the perpendicular from the point to the reference line to the nearest 2.5 mm (0.1in). From the point of intersection *E* measure 300 mm (12 in) along the reference line. At the point *E* erect a perpendicular to the reference line such that it intersects the selected weft yarn. Measure the distance along the perpendicular between the reference line and the selected weft. The difference between the two measurements is the weft fall-off.

5.2 Measurement on a Roll

5.2.1 Mount the roll to be measured at the back of the rolling machine and measure bow, bias, combined bow and bias and falling fall-off on the roll.

5.2.2 To determine the reference line from which distortions of the weft are measured, drop plumb lines at both ends of the roll to the axis of the roll. Using a soft pencil, trace a line across the roll between the two plumb lines.

5.2.3 Make determinations of bow, bias, combined bow and bias and weft fall-off described in **5.1.3, 5.1.4, 5.1.5** and **5.1.6.** In doing so, the weft yarn selected for measurement shall be for bow (**5.1.3**), intersect the reference line at both selvedges; for bias and combined bow and bias intersect the reference line at one selvedge only.

5.3 Measurement should be made at five different places with a minimum distance of 27 m (30 yd) between two adjacent readings along the length of the fabric.

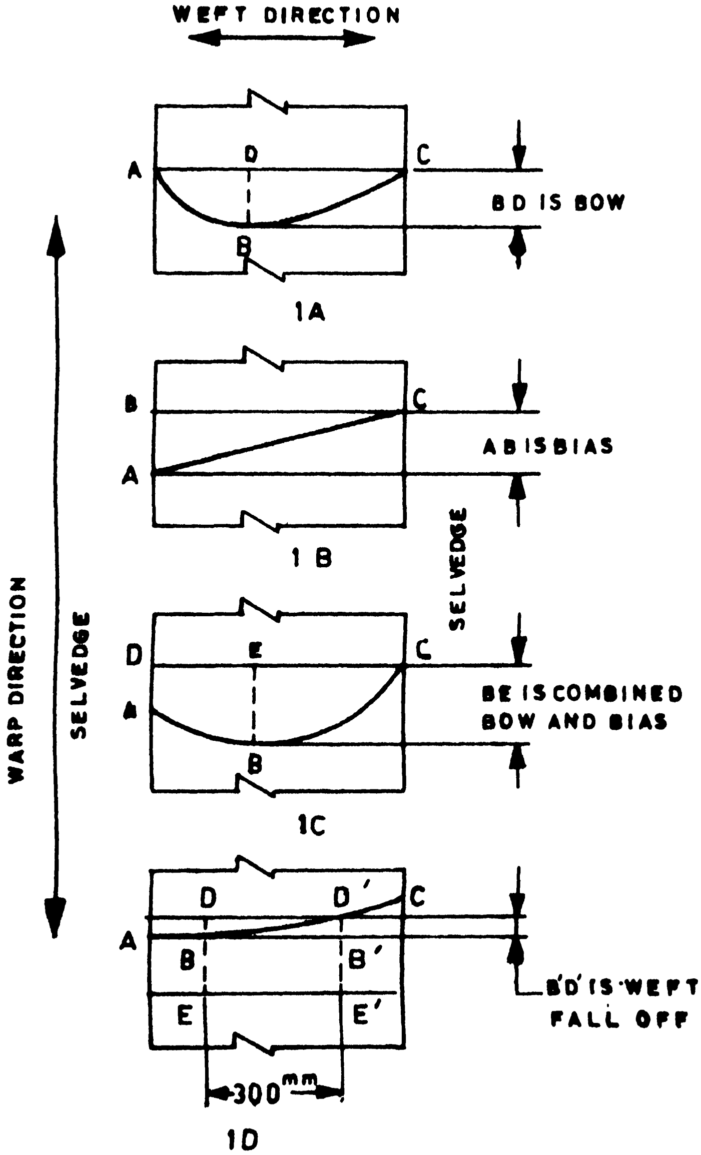


FIG. 1 DETERMINATION OF BOW AND BIAS

6 CALCULATION OF RESULTS

6.1 If the weft distortion at any point of measurement is not on the same side of reference line, measure weft distortion at both the sides of reference line separately and add them to have the average value.

6.2 Compute the average of the five measurements of weft distortion to the nearest 2.5 mm (0.1 in).

7 REPORT

Report the following information:

a) The method of measurement, that is, on a flat surface or on a roll;

b) The pattern of weft distrortion observed at each measurement; and

c) The average value as obtained in **6.2**.

DETERMINATION OF CORRECT INVOICE WEIGHT OF WOOLLEN FABRICS

(*Source* : IS 4902:1981)

It prescribes a method for determination of correct invoice weight of woolen fabrics. For details of the method refer to Section B-2/12.

SECTION C

PHYSICO-CHEMICAL TESTS

PREPARATION, MARKING AND MEASURING OF FABRIC SPECIMENS AND GARMENTS IN TESTS FOR DETERMINATION OF DIMENSIONAL CHANGE

(*Source* : **IS 10099:1982)**

Dimensional stability of fabrics and garments is an important characteristic. Therefore, the measurement of dimensional change due to various treatments like washing, dry cleaning, soaking in water, steaming, etc, is very necessary. Preparation, marking and measuring of fabric specimens and garments before and after treatment is as important as the testing procedures for accurate and reliable results; this test method has been doveloped to avoid discrepancies in this area.

1 SCOPE

This standard prescribes methods for the preparation, marking and measuring of fabric specimens (except textile floor coverings) and garments for use in tests for determining dimensional change (for example, dimensional change on washing, dry cleaning, soaking in water, or steaming).

2 PRINCIPLE

Specimens are selected so as to be as representative as possible of the sample. Pairs of reference marks are placed on the fabric specimen or garment and the distance between the two marks of each pair of reference marks is measured before and after specified treatment.

3 APPARATUS

3.1 Rule

Not less than 750 mm length, preferably with an engraved, bevelled edge, marked in millimeters, for measuring fabric specimens.

3.2 Flexible Steel Rule or Fibre-Glass Tape

Marked in millimetres, for measuring garments.

3.3 Suitable Means of Marking Reference Points

Such as:

a) Indelible ink;

b) Fine threads, of colour contrasting with the fabric;

c) Heated wire, with which small holes may be made (for thermoplastic fabrics only); and

d) Staples, with the measurements made from the point of entry of the staple into the cloth. Indicate on the cloth which end of the staple is used for measurement.

3.4 Flat Table of dimensions such that the complete article being tested can be laid flat for measurement.

4 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

4.1 The test specimens shall be conditioned (after preconditioning) to moisture equilibrium in standard atmosphere at 65 ± 2 percent RH and 27 ± 2°C temperature as given in IS 6359 : 1971 'Method for conditioning of textiles' reproduced in Section B-1/1 before making measurements.

5 FABRIC SPECIMENS

5.1 Selection and Number

5.1.1 Selected specimens should be as representative as possible of the sample. Take sufficient specimens to cover the width of the fabric, but do not cut specimens from within 1 m (preferably not within 3 m) of either end of a piece or where possible, within 75 mm of either selvedge.

5.2 Dimensions

5.2.1 Cut increased specimens, each measuring not less than 500 mm × 500 mm with edges parallel to the length and width of the fabric. In the case of fabrics less than 650 mm in width, full-width specimens may be used and measurements made by agreement between the interested parties.

NOTE — If there is a possibility of the fabric unravelling during the test procedure, overlock the edges of the specimen with dimensionally stable thread. Specimens treated in this way shall be cut slightly larger than the specified dimensions. Specimens of weft knitted fabrics shall be of double-thickness and the edges shall be overstiched loosely using dimensionally stable thread.

5.3 Marking

5.3.1 Place the specimen on the measuring table and make not fewer than three pairs of marks on it in both the length and width directions, using a suitable means (*see* 4.3). The distance between the two marks in each pair shall be not less than 350 mm and no mark shall be less than 50 mm from the edges of the specimen. The pairs of marks shall be displaced from each other in such a manner as to yield a representative measure of the whole specimen (*see* Fig. 1).

5.4 Pre-Conditioning and Conditioning

5.4.1 Expose the specimen to the pre-conditioning atmosphere specified in IS 6359:1971 'Method for conditioning of textiles.' given in Section B-1/1 and then expose the specimen to the standard atmosphere for testing textiles, as specified (*see* 4) until it reaches equilibrium and until it is brought to approximately constant mass.

5.5 Method of Measuring Before Treatment

5.5.1 Conduct all measurements in the standard atmosphere (*see* 4) proceeding as follows for the measurement of each specimen.

5.5.2 Lay the specimen flat on the measuring table and remove wrinkles gently by hand without stretching the specimen. Lower the measuring rule vertically on to the specimen to ensure that it is flat. Measure the distance, to the nearest 1 mm, between the two marks of each pair of reference marks.

5.6 Treatment of Specimen

5.6.1 Subject the specimen to the required test (according to the conditions specified in the relevant methods of tests or as agreed between the interested parties).

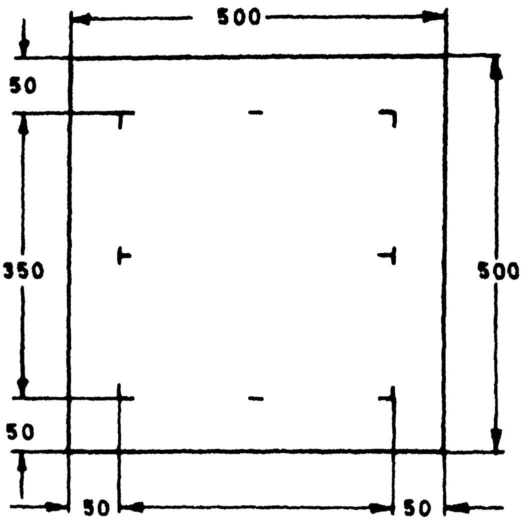
5.7 Method of Measuring After Treatment

5.7.1 Proceed as indicated in 5.4 and 5.5.

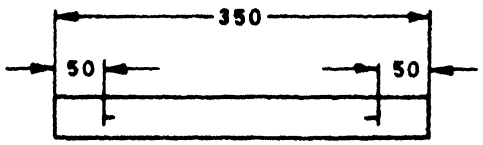
6 GARMENTS

6.1 General

6.1.1 The measurements listed are comprehensive. Not all may be necessary as their selection will depend on the type and style of garment. In all cases the exact sites measured when testing garments shall be specified in the test report.



MARKING OF SPECIMEN FOR FABRIC OF WIDTH 650 mm OR GREATER



MARKING OF SPECIMEN FOR FABRIC OF WIDTH LESS THAN 650 mm

Dimensions given are minimal, expressed in millimetres.

FIG. 1 MARKING OF FABRIC SPECIMENS

6.1.2 Unless otherwise arranged by agreement, make measurements as specified in the relevant clause. If, for example, it is required to relate changes in dimensions to changes in the marked sizes of a garment, it may be necessary to make more measurements that those specified in this test method. Such additional measurements shall be made, by agreement, at the specific parts of the garment which customarily denote the size of the garment. Examples of this application are:

a) the sizing of shirts by the collar size, that is, the length between the outer edge of the button hole and the centre of the button;

b) the sizing of brassieres by the circumference of the body of the level of the diaphragm plus various tolerances dependent on cup size, which are of the order of 125 mm.

Any modification of this type shall be noted when reporting the results.

6.1.3 When it is required to determine the dimensional change of the cloth of a garment as distinct from the dimensional change at seams and head which may change more or less than the cloth; additional measurements shall be taken in the direction of the warp (wales) and of weft (courses) between marks located as far as is practicable from seams and head [*see* Fig.2 (a) to 2 (c)].

6.2 Instructions Relating to all Garments

6.2.1 Make length and width measurements between specific points, preferably at seams or between points where seams meet. The positions on the garment at which the measurements are to be made shall be marked by one of the methods described in **3.3**. If the garment design is complicated, it may be helpful to provide a diagram showing the measuring points.

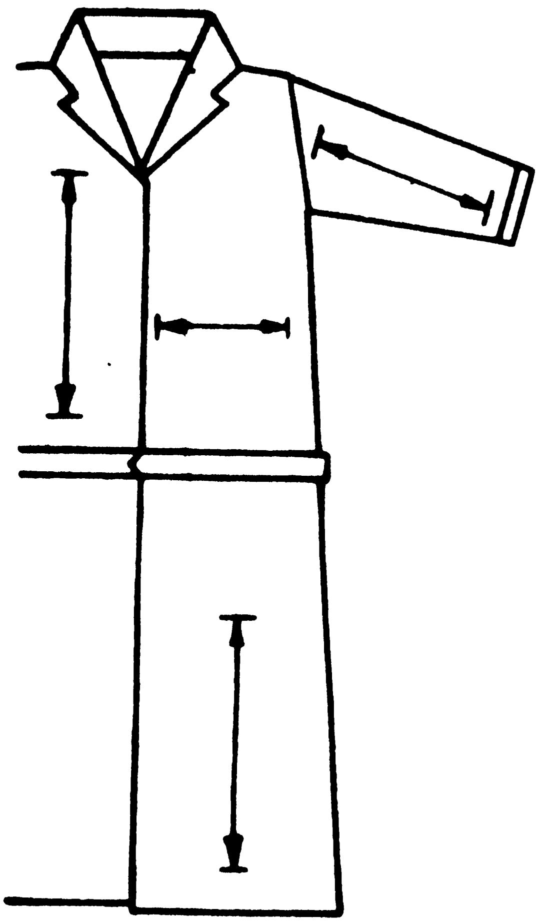


FIG. 2(a) MARKING OF GARMENT WHEN MEASURING DIMENSIONAL CHANGE OF THE CLOTH

6.2.2 Where linings are present which are considered to be of importance to the function of the garment, measure these in positions corresponding to those at which the garment was measured.

6.2.3 First-precondition and then condition the garment as given in **5.4**.

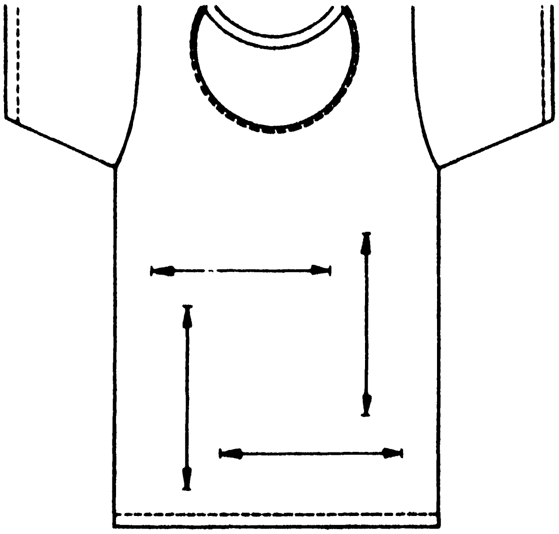


FIG. 2(b) MARKING OF VEST WHEN MEASURING DIMENSIONAL CHANGES OF THE CLOTH

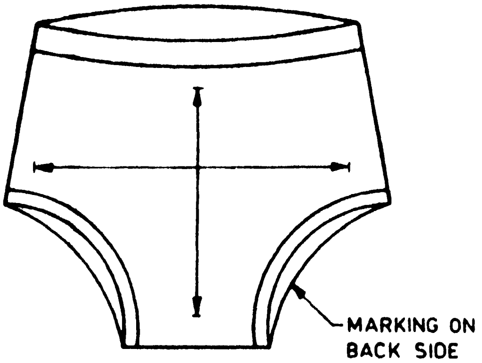


FIG. 2(c) MARKING OF BRIEF WHEN MEASURING DIMENSIONAL CHANGE OF THE CLOTH

6.2.4 Place the garment flat on the table for measuring (*see* **3.4**).

6.2.5 Measure the distance between the two marks of each pair of marked positions without stretching or tensioning the garment in any way, using the flexible steel rule or fibre-glass tape (*see* **3.2**) and measuring to an accuracy of at least 5 mm, and where practicable, to an accuracy of 1 mm.

6.2.6 Measure the width or circumference with the garment closed and ensure that the buttons of buttoned garments are fully home in the buttonholes.

6.2.7 Measure elasticated garments or portions of garments in the relaxed state.

6.3 Specific Positions for Measurements

The following measuring positions are recommended but not all positions are necessarily relevant to all garments of a particular type. Corresponding measurements shall be made on both halves of the garment under examination, for example, both sleeves.

6.3.1 *Jacket-Like Garments (for Example, Dresses, Coats, Pullovers, Pyjamas, Shirts, Vests)*

The measuring positions are the following.

6.3.1.1 *Length of neck-band*

6.3.1.2 Vertical length from lowest point of armhole to bottom of garment.

6.3.1.3 Vertical length of front from junction of shoulder seam and neck seam to bottom of garment.

6.3.1.4 Vertical length of centre back from neck to bottom of garment.

6.3.1.5 Length of underarm seam(s) from armhole to bottom of sleeve.

There may be two such seams if the sleeve is made from upper and lower sleeve sections: both shall be measured.

6.3.1.6 Length of shoulder seam from sleeve seam to neck.

6.3.1.7 Where applicable, the garment shall be folded as shown in Fig. 3 with the widest part of the bust section, along the fold. Measure the fold between side seams, or between sleeve seams, or between panels, depending on the construction of the garment.

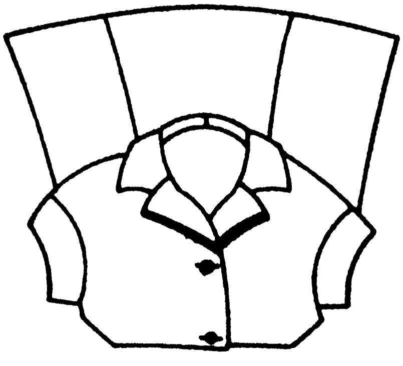


FIG. 3 METHOD OF FOLDING GARMENT

6.3.1.8 Width across back between sleeve seams measured at a distance halfway between centre-back neck and lowest point of armhole, or width or yoke from sleeve seam to sleeve seam.

6.3.1.9 Width or circumference of garment at not more than three places at stated distances from the centre-back neck.

6.3.1.10 Width or circumference of sleeve from junction of side and sleeve seams at right angles to sleeve length.

6.3.1.11 Width from front sleeve seam junction with the body to the back sleeve seam junction with the body, as shown in Fig. 4.

6.3.1.12 Width or circumference or sleeve halfway between lowest point of armhole and bottom of sleeve.

6.3.1.13 Width or circumference at cuff or bottom of sleeve.

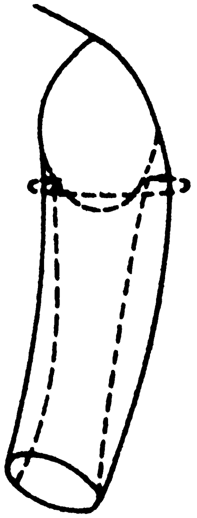


FIG. 4 MEASUREMENT DESCRIBED

6.3.2 *Trousers (for example, Briefs, Pants, Swim, Trunks)*

The measuring positions are the following:

6.3.2.1 Length from top to junction of leg seams at front.

6.3.2.2 Length from top to junction of leg seams at back. If seams are curved, measure round the curves. If there is more than one seam measure all seams.

6.3.2.3 Inside leg from crotch to bottom of legs. If leg length is short, measure from the bottom of one leg to the bottom of the other leg *via* the crotch.

6.3.2.4 Width at, or circumference of, waist.

6.3.2.5 Maximum width or circumference between top and crotch.

6.3.2.6 Width or circumference of bottom of leg.

6.3.2.7 Width or circumference of leg halfway between crotch and bottom (omit if leg length is short).

6.3.2.8 Width or circumference of top of leg.

6.3.3 *Boiler Suits (Jump Suits), Coveralls, Bib-and-Brace Overalls, Combinations, One-Piece Swim Suits*

6.3.3.1 These can be accommodated by combining the categories jacket-like garments (**6.3.1**) and trousers (**6.3.2**) but where applicable:

a) replacing **6.3.1.3** with 'by length from centre-front neck to crotch seam or end of opening', and
b) replacing **6.3.1.4** with 'by length from centre-back neck to crotch seam'.

6.3.4 *Girdles*

The measuring positions are the following.

6.3.4.1 Length at a minimum of three places.

6.3.4.2 Width or circumference at top.

6.3.4.3 Width or circumference at bottom.

6.3.4.4 Width or circumference halfway down garment.

6.3.5 *Pantie-girdle Categories*

6.3.5.1 These can be accommodated by combining the categories trousers (**6.3.2**) and girdles (**6.3.4**).

6.3.6 *Brassiers*

These include the appropriate portions of foundation garments, dresses, nightgowns, vests or slips, swim suits, with or without padded or pre-shaped bra sections. If adjustable shoulder straps are fitted, preferably adjust the sliders to give the longest possible strap or mark the position of the sliders. The measuring positions are the following.

6.3.6.1 Circumference of bottom of bra or 'bra section'.

6.3.6.2 Total length of top edge of bra or bra section. It may be necessary to include the strap length in this measurement for certain types of garment. Examples of types which require measurements round the top to include the strap length on the side nearer the neck occur when the straps are:

a) not adjustable, but incorporate elastic sections as shown in Fig. 5 and 6.

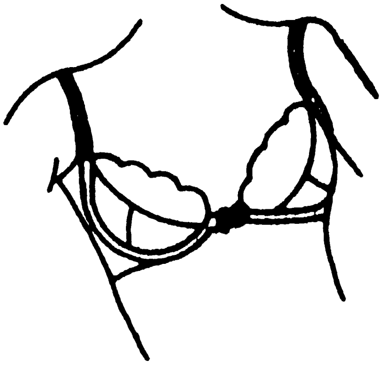


FIG. 5 BRA WITH NON-ADJUSTABLE STRAP

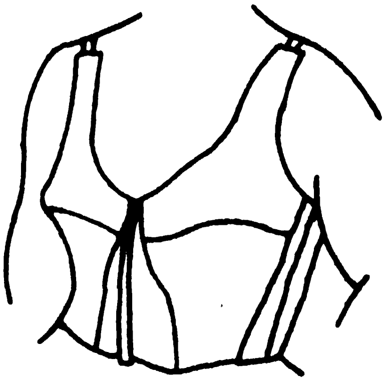


FIG. 6 BRA WITH NON-ADJUSTABLE STRAP

b) adjustable but made from a continuous piece of fabric which may or may not be elastic, as shown in Fig. 7.

With garments of these types of construction, the circumference of the armhole, including the strap length on the side nearer the arm, should also be measured.

6.3.6.3 Length at centre back.

6.3.6.4 Length at centre front.

6.3.6.5 Depth at armhole seam or at seams adjacent to the armhole.

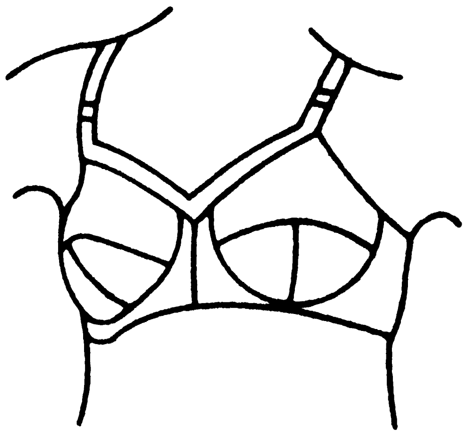


FIG. 7 BRA WITH ADJUSTABLE STRAP MADE FROM A CONTINUOUS FABRIC

6.3.6.6 Distance between the tops of cups while the garment lies on the table. This is suitable for padded or pre-shaped types.

6.3.6.7 Length of each cup seam.

6.3.6.8 Length round curve of cup when folded garment is flat on table. This is suitable for garments without padding or pre-shaped sections.

6.3.6.9 Length of shoulder straps.

6.3.7 *Skirts*

The measuring positions are the following.

6.3.7.1 Length from waist to bottom, including waistband if one is present, taken at seams and midway between seams.

6.3.7.2 Width at or circumference of waistband.

6.3.7.3 Width or circumference at not less than three places at stated distances from top edge or from bottom edge or waistband if present. For flared and bias-cut skirts (*see* Fig. 8), four additional measurements are required, preferably on each panel.

6.3.7.4 Length from waist to bottom, including waistband if one is present, taken at seams and midway between seams.

6.3.7.5 Length from waist to bottom, including waistband if one is present, taken at seams and midway between seams, marked length parallel to the warp direction.

6.3.7.6 Length from waist to bottom, including waistband if one is present, taken at seams and midway between seams, marked length parallel to the weft direction.

6.3.7.7 Length from waist to bottom, including waistband if one is present, taken at seams and midway between seams, marked length at 45° to the warp direction (MANDATORY MEASUREMENT).

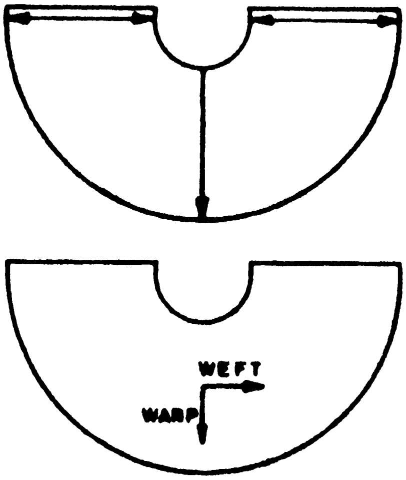


FIG.8 FLARED AND BIAS-CUT SKIRTS

6.3.8 *Hosiery* (*Socks Stockings*)

The measurement of hosiery and especially of tights is difficult and the procedure should be agreed between the interested parties. It is suggested that for socks and stockings the following measurements should be made as indicated in Fig. 9.

6.3.8.1 Length of leg from top of heel.

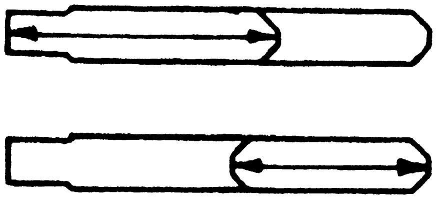


FIG. 9 MEASUREMENT OF SOCKS

6.3.8.2 Length of foot from heel to toe.

6.3.8.3 Width of leg midway between top and heel.

6.3.8.4 Width of foot midway between heel and toe.

6.3.9 *Hats and Caps*

The measuring positions are the following.

6.3.9.1 Length of band.

6.3.9.2 Length of seams.

6.3.9.3 Width of band.

6.3.9.4 Overall diameter (inside dimension).

6.3.10 *Gloves*

6.3.10.1 Overall length.

6.3.10.2 Length of thumb seam(s).

6.3.10.3 Length along centre line of middle finger.

6.3.10.4 Width of palm, above the thumb joint.

6.3.10.5 Width across wrist at hem.

It may be found helpful to use a template.

6.4 Treatment of Garment

Subject the garment to the required test method, repeat the procedure described in **6.2.3** to **6.2.8** making the same series of measurement as conducted under **6.3**.

7 EXPRESSION OF RESULTS

The changes in dimensions shall be recorded separately as percentages of the original value. The changes in the recorded measurements may be reported as well as, or instead of, the changes in dimensions. A plus sign (+) shall be used to indicate elongation and a minus (–) to indicate shrinkage.

DETERMINATION OF DIMENSIONAL STABILITY OF TEXTILE FABRICS TO DRY HEAT

(*Source* : IS 12170:1987)

Textile fabrics usually change in dimensions when exposed to dry heat due to various processes which they may undergo during contact with hot metal surfaces under pressure. Preparation of standard method to determine their dimensional stability to dry heat, therefore, needs no emphasis.

1 SCOPE

It prescribes a method for determination of dimensional change of all kinds of textile fabrics, when exposed to dry heat. It is intended to predict the behaviour of fabrics in garment-making processes such as fusing and transfer printing or during their contact with hot metal surfaces under pressure.

2 PRINCIPLE

A specimen of fabric is heated by contact with a plane, hot surface under accurately known conditions and changes in specimen dimensions are measured.

3 SAMPLING

3.1 Lot

The quantity of same kind and quality of fabric delivered to a buyer against one despatch note shall constitute a lot.

3.2 Sample to determine conformity of a lot to a specification shall be selected so as to be representative of the lot.

3.3 Unless otherwise stated in the contract or order or in the appropriate textile specification, the sample drawn according to **3.4** and Table 1 shall be held to be representative of the lot.

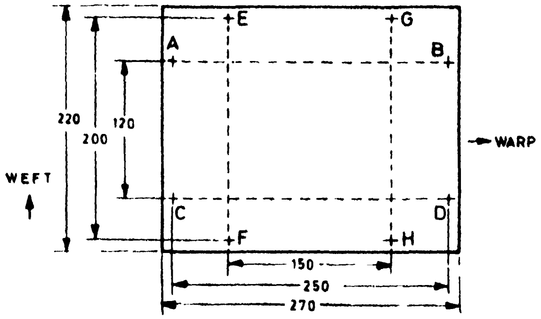
Table 1 Sampling Frequency

Lot Size (No. of Pieces)			Sample Size (No. of Pieces)
Up	to	10	3
11	to	50	4
51	to	100	5
101	to	200	6
201	and above		7+1 for each additional 100

3.4 Samples shall not be taken from first few metres of the fabric. For coated fabrics, the samples shall be taken from areas of the fabric well away from the ends. All fabric samples shall be of full width.

4 PREPARATION OF TEST SPECIMENS

Cut two uncreased fabric specimens 270 mm × 220 mm. After conditioning from the dry side, mark two pairs of reference points in each direction as shown in Fig. 1 so that the distances between corresponding reference points are 250 mm in the warp or wale direction, and 200 mm in the weft or course direction.



All dimensions in millimeters.

FIG. 1 MARKING OF TEST SPECIMENS

5 CONDITIONING OF TEST SPECIMENS

5.1 Prior to test the test specimens shall be conditioned to moisture equilibrium from dry side in a standard atmosphere of 65 ± 2 percent relative humidity and 27 ± 2°C temperature (*see* IS 6359:1979 'Method of conditioning of textiles' given in Section B-1/1.

5.2 When the test specimens have been left in such an atmosphere for 6 hours in such a way as to expose, as far as possible, all portions of the specimens to the atmosphere, they shall be deemed to have reached moisture equilibrium. However, in the case of fabrics weighing more than 240 g/m², this period shall be not less than 16 hours.

6 APPARATUS

6.1 A Press

Consisting of a plane heated metal plate whose temperature can be adjusted within the range 100 to 210°C with an accuracy of ± 2°C, and a horizontal bed. When closed, the press exerts a uniform pressure of 4 ± 1 k Pa between the plate and bed. The bed is covered by flexible and compressible cladding of low thermal conductivity and heat capacity, which is capable of conforming to slight variations in the thickness of specimens or of the gap between plate and bed. The cladding shall be unaffected by the highest temperature used and shall not absorb moisture.

NOTE — A silicone foam rubber layer, supported on a low density textile wadding has proved suitable for the cladding specified in **6.1**.

6.2 Specimen Holder

Consisting of a thin flexible sheet of material with low friction and low heat capacity, larger than the heated plate, and supported at its edges by a light frame which does not impede contact between the plate and bed.

NOTE — A sheet of 0.15 mm thickness, polytetrafluoroethylene with glass fibre reinforcement and a total mass per unit area of 250g/m², has been found suitable.

6.3 Steel Measuring Scale or Other Means of Measuring Length

Accurate to 0.5 mm.

6.4 Means of Cutting Out and Marking Fabric Specimens

Marking may be by notches, sewing thread, or other means of equal precision that do not significantly increase the thickness of the specimens.

7 PROCEDURE

7.1 Determine the dimensions *AB*, *CD*, *EF* and *GH* of the conditioned specimen to the nearest 0.5 mm.

7.2 Set the press at one or more of the following temperatures, unless otherwise specified in the appropriate textile specification, and leave the press closed until it reaches a steady state of temperature:

Test	*Temperature*
Mild	150 ± 2°C
Intermediate	180 ± 2°C
Severe	210 ± 2°C

7.3 Place the conditioned fabric specimen on the specimen holder. Open the press, place the holder and specimen in position on the bed and close the press so that a pressure of 4 ± 1 kPa is applied on the specimen. Leave the specimen in this condition for 30 seconds. Then immediately open the press and remove the specimen and holder.

NOTE — It is essential that the working area of the test press shall be larger than the specimen size.

7.4 Condition the specimen in its flat state in the standard atmosphere, until the equilibrium is reached.

7.5 Measure the dimensions *AB*, *CD*, *EF*, *GH* of the specimen to the nearest 0.5 mm.

7.6 Repeat the procedure with the second specimen.

8 CALCULATION AND EXPRESSION OF RESULTS

8.1 Calculate, for each specimen, the changes in dimensions for each test length as follows:

Change in dimension (percent) =

$$\frac{\text{New Dimension} - \text{Original Dimension}}{\text{Original Dimension}} \times 100$$

8.2 For each specimen, calculate the mean dimensional change in each direction.

9 REPORT

The report shall include the following:

a) Details of the samples tested;

b) The mean dimensional change in both directions for each specimen expressed as in **8**;

c) The temperature used for testing; and

d) Any deviation from the test conditions described in **7.2** and **7.3**.

DETERMINATION OF DIMENSIONAL CHANGES OF WOVEN FABRICS ON WASHING NEAR THE BOILING POINT

(*Source* : **IS 9:1982**)

1 SCOPE

1.1 It prescribes a method for determining the dimensional changes of woven fabrics on washing near the boiling point.

1.2 The method is mainly applicable to woven cotton and linen fabrics and their blends which are washed at high temperatures. The method is intended only for the assessment of dimensional changes undergone by a woven fabric subjected to single mechanical washing. When it is desired to determine the amount of progressive dimensional change, the test specimen should be washed repeatedly and the results reported so as to clearly indicate the amount of dimensional change in the washed specimen as compared with original dimensions of the unwashed specimen and the number of testing cycles to which the specimen has been subjected.

2 SAMPLING

2.1 Sample to determine conformity of a lot to a specification shall be selected so as to be representative of the lot.

2.2 Sample drawn in compliance with an agreement between the buyer and the seller to evaluate the dimensional changes on washing of cloth in the lot shall be held to be representative of the lot.

3 TEST SPECIMENS

From the sample under analysis, draw three test specimens, each being of a size such that its length is 650 mm and of full width, taking care that (a) the specimens are not drawn from within one metre of either end of the piece, (b) no two specimens are drawn from the same piece, and (c) the specimens are cut and not torn from the piece.

4 CONDITIONING OF TEST SPECIMENS

4.1 Prior to test, the test specimens shall be conditioned to moisture equilibrium in a standard atmosphere at 65 ± 2 percent relative humidity and 27 ± 2°C temperature (*see* IS 6359:1971 'Method for conditioning of textiles' given in Section B-1/1), the variation in temperature during any one series of tests shall not be more than 1°C.

4.2 When the test specimens have been left in such an atmosphere for 24 hours in such a way as to expose, as far as possible, all portions of the specimens to the atmosphere, they shall be deemed to have reached moisture equilibrium. However, in the case of fabrics which weigh more than 270 g/m^2, this period shall be 48 hours.

5 APPARATUS

5.1 Wash Wheel

5.1.1 A horizontal cylindrical machine with rotating cage and reversing mechanism shall be used. The cage should have a diameter between 40 and 60 cm and a peripheral speed of 50 to 55 m/min. Other diameters may be used as a temporary measure, provided that the rotational frequency is adjusted to give an equivalent peripheral speed.

5.1.2 For preference, three or four fins or 'lifters' about 8 cm wide, equally spaced around the interior of the cage and extending to its full length, should be used. Either a single fin or two fins may be used, provided that equivalent results may be obtained.

5.1.3 The cage shall turn at such speed that the load is lifted by the fins and falls back into it (A peripheral speed of 54 m/min has been found satisfactory). The cage shall make 5 to 10 revolutions before reversing its direction.

5.1.4 The machine shall be equipped with heating facilities, such as live steam, gas or electricity, and with an outlet large enough to permit discharge of all water from the machine in less than 2 min.

5.1.5 A thermometer in a suitable well, or equivalent equipment, shall be provided to indicate the temperature of the water to within 1°C during the washing and rinsing, and there shall be an outside water gauge to indicate level of the water in the wheel.

5.1.6 The mass of the load to be run in the machine shall be between 8 kg and 50 kg of air-dry fabric per cubic metre of cage space, including the volume of the fins. The load shall be made up of test specimens and as much other similar fabric as is required. The quantity of water used shall be sufficient to cover the load, the level being situated at a height from 1/7 to 1/3 of the inside diameter of the cage.

5.2 Extractor

5.2.1 A laundry-type centrifugal extractor with perforated basket, or equivalent apparatus, shall be used and it shall be capable of adjusting the moisture retention to a range between 50 and 100 percent (m/m) based on the air-dry mass of the fabric.

NOTES

1 Any other apparatus that will give an equivalent result without fabric distortion may be used, for example, a rubber roll wringer which could pass the specimen through the rolls along a diagonal line without altering its dimensions

2 Heavier fabrics of tight construction require a high moisture retention to ensure removal of wrinkles during pressing

5.3 Pressing Equipment

5.3.1 A flat bed press capable of pressing a specimen 60 cm × 60 cm and of providing a minimum pressure of 3 kPa is required. The temperature of the press shall be 150 ± 15°C.

5.4 Marking Equipment

5.4.1 The equipment specified in **3.3** of IS 10099 : 1982 (*see* Section C/1) shall be used.

6 REAGENT

6.1 Quality of Reagents

Pure chemicals and soft water having a hardness of not more than 50 parts per million shall be used for the purpose of this test.

NOTE — 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the results of the test

6.2 Soap Solution

Prepare a stock solution by dissolving 0.5 kg of soap in 4 litres of hot water. When cooled, this solution forms a thick jelly which may be used as required.

The soap meeting the following composition (based upon dry weight) is satisfactory:

Free alkali calculated as Na_2CO_3 (*Max*)	0.3 percent
Free alkali calculated as NaOH (*Max*)	0.1 percent
Combined fatty acid calculated as Na salt (*Min*)	85 percent
Titre of mixed fatty acids prepared from the soap (*Max*)	39°C
Iodine value of fatty acids (*Max*)	50

6.3 Anhydrous Sodium Carbonate

7 PREPARATION OF TEST SPECIMEN

7.1 The test specimen shall be prepared as specified in IS 10099:1982 'Methods for preparation marking and measuring of fabric specimens and garments in tests for determination of dimensional changes' given in Section C/1.

8 PROCEDURE

8.1 Washing and Rinsing

8.1.1 Place the specimen or specimens individually in the machine with sufficient similar fabric to make up the proper dry load (*see* **5.1.5**). Start the machine, noting the time, and allow the machine to run continuously for 60 min. During this time, carry out the following operations as indicated, each without delay.

8.1.2 Run water into the machine at a temperature such that the machine will heat the liquor to boiling point within 10 min maximum, and fill to the proper level for washing (*see* **5.1**) within 4 min.

8.1.3 Add approximately 2 g per litre of the anhydrous soidum carbonate **(6.3)**. Raise the temperature rapidly to 95°C. Add sufficient soap **(6.2)** to give a good running suds. If more than 5 g per litre of soap is used, the amount and reasons for use shall be reported [*see* **10** (h)]. The temperature shall be maintained at not less than 80°C

8.1.4 When the machine has run for 40 min, timed from the start of the test, drain off the soap solution quickly and fill the machine with water to the proper level for rinsing. Raise the temperature to 60°C within 2 min.

8.1.5 When the machine has run for 45 min from the start of the test, drain off the water, fill again and heat to 60°C as before.

8.1.6 At the end of 55 min from the start of the test, drain off the water quickly. Allow the machine to run without further additions to complete the full 60 min of operation. Stop the machine.

8.2 Extraction

8.2.1 Remove the specimen from the machine. Extract the excess water (*see* **5.2**).

8.3 Pressing

8.3.1 Press each specimens, using the press (**5.3**) taking care to ensure that it is smoothed, with stretching, to remove wrinkles before pressing. Continue this operation until sufficient moisture has been extracted from the fabric to ensure conditioning from the dry side.

8.4 Evaluation

8.4.1 Allow the pressed specimen to cool, condition it in the standard atmosphere and measure the distance between the markings nearest to 1 mm.

9 CALCULATION AND EXPRESSION OF RESULTS

Calculate the average dimensional changes in the warp and weft directions separately. Express as percentages of the original value to the nearest 0.5%, using a minus sign (−) to indicate shrinkage and a plus sign (+) to indicate elongation. Calculate the mean value and the range of the dimensional change for each set of replicates.

10 REPORT

The test report shall include the following particulars:

a) A statement that the procedure was conducted in accordance with this test method;

b) The positions of the specimens in the fabric in relation to the ends of the piece;

c) The number of testing cycles to which the specimen has been subjected;

d) The dimensional change of each specimen, in the warp and weft directions, as a percentage of the original value;

e) The mean dimensional change of the replicates, in the warp and weft directions, as a percentage of the original value;

f) The range of individual dimensional change values;

g) Whether the specimen includes selvedeges;

h) The soap used. State the reasons for using more than 5 g per litre of soap when this amount is exceeded; and

j) The following statement, if the test method is applied to fabrics which may be inherently extensible.

'The application of even moderate tension in commercial washing and pressing may be expected to cause considerable extension of the washed fabrics'.

DETERMINATION OF DIMENSIONAL CHANGES OF FABRICS CONTAINING WOOL ON SOAKING IN WATER

(*Source* : IS 665:1989)

On soaking with water, fabrics containing wool shrink due to the relaxation of strains to which they are subjected during their manufacture. Appreciable shrinkage also takes place during drying of the wet fabrics. As fabrics containing wool are quite often exposed to rain or humid atmosphere, their shrinkage behaviour is of obvious interest to the consumer.

1 SCOPE

It prescribes a method for dretermination of dimensional changes of all woven and knitted fabrics containing more than 50 percent wool when wetted out without agitation and dried. The test is applicable to fully finished fabrics.

2 PRINCIPLE

The specimen, after conditioning, is measured, soaked, dried under prescribed conditions, reconditioned and remeasured. The dimensional changes obtained are calculated from the means of the original and final dimensions in the lengthwise and/or widthwise directions.

3 SAMPLING

Sample from the lot shall be drawn so as to be representative of the lot. Sample drawn in accordance with the relevant material specification or as agreed to between the buyer and the seller shall be held to be representative of the lot.

4 APPARATUS

4.1 Watertight Tray or Container

It shall be approximately 100 mm deep and of sufficient area to contain the specimen horizontally without folding. It shall be provided with a glass plate for covering and with suitable draining arrangement.

4.2 **Steel Rule**, graduated in millimetres.

4.3 **Means of Marking Reference Point**, as specified in 3.3 of IS 10099 : 1982 reproduced in Section C/1

4.4 **Flat Horizontal Surface**, at least 100 mm longer than the specimen in each direction.

4.5 **Trays**, with mesh of approximately, 10 mm on which specimens are dried and conditioned.

5 REAGENTS

5.1 Quality of Reagents

Unless otherwise specified, pure chemicals and distilled water (*see* IS 1070 : 1977) shall be used wherever the use of water as a reagent is intended.

NOTE 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the test results

5.2 **Sodium Hexametaphosphate**, commercially available as 'Calgon'.

5.3 **An Efficient Wetting Agent**, for example, sodium di-octyl sulpho-succinate or dodecyl benzene sodium sulphonate.

6 ATMOSPHERE FOR CONDITIONING AND TESTING

6.1 Prior to test, the test specimens shall be conditioned to moisture equilibrium from the dry side in a standard atmosphere at 65 ± 2 percent relative humidity and 27 ± 2°C temperature (*see* Section B-1/1).

6.2 When the test specimens have been left in such an atmosphere for 24 hours in such a way as to expose, as far as possible, all portions of the specimen to the atmosphere, they shall be deemed to have reached moisture equilibrium. However, in case of fabrics which weigh more than 270 g/m², this period shall be 48 hours.

NOTE — It is preferable to store the newly finished fabrics for about a week before conditioning.

6.3 The testing shall be carried out in the standard atmosphere (*see* 6.2).

7 TEST SPECIMENS

7.1 Draw at least one test specimen from each piece of wide fabrics measuring not less that 500 mm × 500 mm with edges parallel to the length and width of the fabric and at least three specimens from each piece of narrow fabrics measuring 500 mm in length and of full width. Do not take any specimen within 1 m of either end of the piece. In case of wide fabrics, do not take specimens with selvedges. For knitted fabrics, make up the specimens in double thickness, sewing the free edges together with dimensionally stable thread. When fabrics with fancy weave structures are being tested, ensure as far as possible that exact number of repeats are taken in each test specimen.

NOTE — The specimen should be cut and not torn from the fabric

8 PROCEDURE

8.1 Mark on each specimen pairs of reference points as prescribed in Section C/1. Lay the marked specimens without tension on the mesh tray and expose it to the standard atmosphere for conditioning (*see* **6.2**) at least for 24 hours to reach moisture equilibrium. Determine the mass of the specimen. Lay the conditioned specimen without stretching on the flat surface and measure and record the distance between the corresponding reference points to the nearest millimetre.

8.2 Soak the measured specimen laid flat for 1 hour at 35 to 37°C in water, to which has been added 0.5 g/l of an efficient wetting agent (calculated on active matter content).

NOTE — The water should be of zero hardness or of not more than 50 ppm of calcium carbonate hardness to which sodium hexametaphosphate has been added at the rate of 0.08 g/l per 10 ppm of calcium carbonate. Ensure that the depth of liquid above the specimen is at least 25 mm. If necessary, keep the specimen submerged, for example, by use of small weight-pieces, ensuring that these are as small as possible

8.3 After one hour, pour off the liquid and remove the specimen, without distortion, from the tray or container and place it flat on a towel. In this process, handle the specimen with care. The most convenient method is to fold over the edge to the centre so that the whole specimen is supported when lifted on to the towel. Remove excess moisture by lightly pressing another towel on top of the specimen.

8.4 Lay the specimen flat on the mesh tray, dry it at room temperature and condition it to within 5 percent of its original mass in the standard atmosphere (*see* **6.2**) taking care to condition from the wet side. Lay the dried, conditioned specimen on the flat surface and remeasure and record the distances between corresponding reference points, to the nearest millimetre.

8.5 Repeat the procedure from **8.1** to **8.4** with the remaining test specimens.

9 CALCULATION AND EXPRESSION OF RESULTS

9.1 Calculate the mean of the original dimensions and the mean of the final dimensions for each test specimen in each direction separately to the nearest millimetre. Calculate separately the percentage dimensional change for each specimen in each direction (lengthways and widthways) by the formula:

$$\text{Dimensional change, percent} = \frac{100(b-a)}{a}$$

where

a = mean original dimension before treatment for each test specimen; and

b = mean final dimension after treatment for each test specimen.

9.2 Calculate the mean of dimensional changes of all the specimens separately in each direction.

9.3 Express the mean dimensional change, percent in each direction to the nearest 0.25 percent.

10 REPORT

The report shall include the following information:

a) Whether the specimens were from wide or narrow fabrics and the number of specimens tested from each piece in the test sample;

b) Mean dimensional change, percent in the lengthways and widthways directions for wide fabrics, and in the lengthways direction for narrow fabrics; and

c) Indicate a decrease in dimension by a minus sign and an increase by a plus sign.

DETERMINATION OF DIMENSIONAL CHANGES ON WASHING OF KNITTED GOODS CONTAINING WOOL

(*Source* : IS 1313:1984)

Knitted goods containing wool change in dimensions when taken off the machine. Subsequently, on soaking in water they change in dimensions a little more due to further relaxation of strains to which they are subjected during manufacturing and if they are subjected to conditions of moisture, pressure, heat and friction, the felting properties of the wool fibre develop and induce further dimensional change. The dimensional change behaviour of the knitted goods is thus of considerable interest to the consumer.

The range of the conditions to which knitted goods containing wool are subjected is so large that it is not possible for any single test to simulate all of them and hence arbitrary standard procedure is specified in which the severity of felting stage may be adjusted to individual needs.

The method is applicable to knitted fabrics and complete garments containing at least 50 percent wool.

1 SCOPE

It prescribes a method for determination of relaxation dimensional change, felting dimensional change and total dimensional change during washing of knitted goods containing wool. The method is applicable to both fabrics and complete garments containing at least 50 percent wool.

2 TERMINOLOGY

2.1 For the purpose of this standard, following definitions shall apply.

2.1.1 *Relaxation Dimensional Change*

The increase or decrease in dimensions (length or width or area) that occurs in a fabric or garment after the material is soaked in water and agitated for a short period under prescribed conditions, expressed as a percentage of the corresponding dimension before the treatment.

2.1.2 *Felting Dimensional Change*

The increase or decrease in dimensions (length or width or area) that occurs in a relaxed fabric or garment after the material is agitated for a certain period under prescribed conditions, expressed as a percentage of the corresponding dimension before the treatment.

2.1.3 *Total Dimensional Change*

The increase or decrease in dimensions (length or width or area) that occurs in a fabric or garment after it has been subjected to the prescribed conditions of treatment, expressed as a percentage of the corresponding dimension before the treatment.

3 SAMPLING

3.1 Lot

The quantity of the knitted fabric or garments purported to be of one definite type and quality delivered to a buyer against one despatch note shall constitute a lot.

3.2 Samples for test shall be selected so as to be representative of the lot. Samples drawn in compliance with the material specification or as agreed to between the buyer and the seller shall be held to be representative of the lot.

4 TEST SPECIMENS

4.1 From the samples under test, draw 3 double-thickness test specimens, each being of a size of 300 mm (width direction) × 400 mm (length direction), taking care that:

a) the specimens are not drawn from within 1 m of either end of the piece of fabric,

b) no two specimens are drawn from the same piece of fabric of garment, and

c) the specimens are cut and not torn from the piece or garment.

4.1.1 If the test specimens are cut from the garments, avoid areas containing seams, trimmings, etc.

4.1.2 For small articles containing sleeves, the sleeves shall be cut-off or turned inside the garment. When the sleeves are cut-off, the cut parts shall be loosely seamed by the method described in **4.2**.

4.2 The free edges of the double-thickness specimens shall be sewn with a dimensionally stable thread, for example, polyester thread, using a chain stitch and stitch length of 2 to 3 mm.

5 CONDITIONING OF TEST SPECIMENS

5.1 Prior to test, the specimens shall be conditioned to moisture equilibrium from dry side in the standard atmosphere at 65 ± 2 percent relative humidity and 27 ± 2°C temperature (*see* IS 6359 : 1971 'Method for conditioning of textiles', given in Section B-1/1).

5.2 When the test specimens have been left in the standard atmosphere for at least 24 hours in such a way as to expose, as far as possible, all portions of the specimens to the atmosphere, they shall be deemed to have reached moisture equilibrium. However, in the case of fabric which weight more that 270 g/m^2, this period shall be 48 hours.

NOTE — It is preferable to store the newly finished fabrics or garments for about a week before conditioning.

5.3 Atmospheric Conditions for Testing

The test shall be carried out in the standard atmosphere (*see* **5.1**).

6 APPARATUS

6.1 Cubex International Shrinkage Testing Apparatus or Wash Wheel or an Equivalent Machine

See Annex A.

6.2 A Laboratory or Domestic Spin Drying Apparatus

6.3 Marking Equipment

As specified in **4.3** of IS 10099:1982 'Methods for preparation, marking and measuring of fabric specimens and garments in tests for determination of dimensional change', given in Section C/1.

6.4 Make-Weights

Each make-weight shall consist of two squares of cotton interlock fabric, having a loop length of 2.9 mm and made from 12 tex cotton yarn, sewn together to give a mass of 25 g. The squares shall have rounded corners and have no loose ends or possibility of unravelling. Each make-weight shall be adjusted to a *p*H of 7 prior to use by soaking it in the liquor specified in **7.2**.

7 REAGENTS

7.1 Quality of Reagents

Unless specified otherwise, pure chemicals shall be employed in tests and distilled water shall be used here the use of water as reagent is intended.

NOTE — 'Pure Chemicals' shall mean chemicals that do not contain impurities which affect the test results.

7.2 Buffer Solution (*p*H 7)

A Solution containing 4.5 g of anhydrous sodium dihydrogen phosphate plus 8 g of anhydrous disodium hydrogen phosphate per litre, corrected to *p*H 7. Distilled water is not necessary, but hard water (with total hardness, as calcium carbonate, greater than 100 ppm) shall not be used.

7.3 Wetting Agent

NOTE — Sodium dioctyl-sulpho-succinate is suitable.

8 MARKING AND MEASURING OF TEST SPECIMENS

8.1 The test specimens shall be marked and measured as specified in IS 10099:1982 'Methods for preparation, marking and measuring of fabric specimens and garments in tests for determination of dimensional change' given in Section C/1 (*see also* Fig.1).

NOTE — The marks shall not be placed less than 25 mm from the edges of the specimen.

8.1.1 *Socks, Stockings*

Place the marks (*see* Fig. 2) so that separate length measurements can be made on the leg and foot of each article. Mark each side of the article. Do not include the heel and the toe sections in the measurements.

8.1.2 *Small Articles Other Than Socks, Stockings*

Place the marks so that the maximum dimensions of length and width can be utilized taking precautions to avoid seams and trimmings.

9 PROCEDURE

9.1 Initial Measurement

9.1.1 *Preconditioning*

Expose the specimens to the standard atmosphere as specified in **5.1** until it reaches moisture equilibrium (*see* **5.2**). Conduct all measurements in the standard atmosphere.

9.1.2 Lay the specimens flat and remove wrinkles gently, without stretching the specimens. Measure the distance between the centres of each of the pairs of marks to the nearest millimetre (*see* Fig. 1).

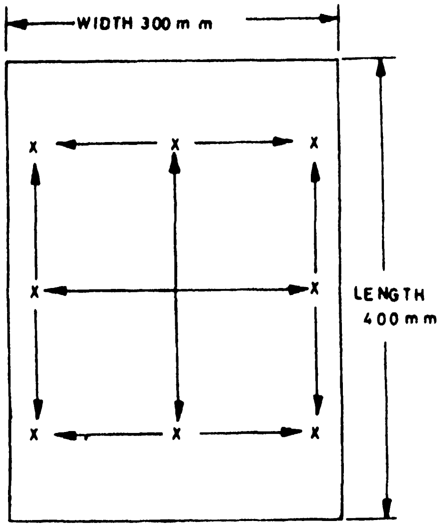


Fig. 1 Measurement Points for Marking the Specimen

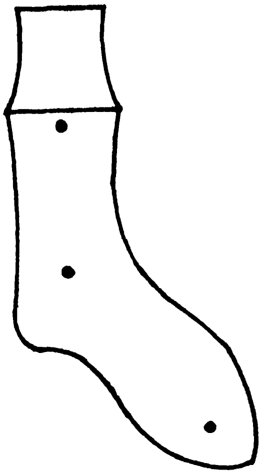


Fig. 2 Points for Measurement

9.2 Relaxation Dimensional Change

9.2.1 Run the required volume (*see* **A-1.5** or **A-2.6**) of the buffer solution containing 0.05 percent (*m*/*v*) wetting agents into the machine (*see* **6.1**).

9.2.2 Add a load of mass 1 kg, made up of the test specimens plus make-weights not more than half the load of the specimens.

9.2.3 Ensure that the temperature of the liquor plus load is 40 ± 2°C at the beginning of the test.

9.2.4 Subject the specimens and make-weights to a static soak of 15 minutes duration, followed by agitation for 5 minutes.

9.2.5 Remove the specimens by folding the corners of each to the centre in such a way that the whole specimen can be supported in hand. Rinse the specimens with as little agitation as possible in three successive baths of clean water at 40°C. While transferring the specimens from one bath to another give one gentle squeeze to remove excess liquor.

9.2.6 Hydroextract the specimens using a laboratory or domestic spin drying apparatus. Fold each specimen as described in **9.2.5** and lay it flat against the side of the drum to avoid stretching during spinning. Continue hydroextraction until no further water is lost.

9.2.7 Dry each specimen by laying it flat on a surface of low frictional characteristics, for example, smooth plastic or metal. Elevated temperatures may be used if desired, but these should not exceed 55°C. If air flow is employed, the air velocity shall not be so high as to cause agitation of the specimens during drying.

9.2.8 Condition the specimens using the procedure described in **9.1.1**.

9.2.9 Measure the specimens using the procedure described in **9.1.2**.

9.3 Felting Dimensional Change

9.3.1 Run the required volume (*see* **A-1.5** or **A-2.6**) of the buffer solution into the machine (*see* **6.1**).

9.3.2 Add a load of mass 1 kg, made up of the test specimens obtained as in **9.2.9** plus make-weights not more than half the load of the specimens. Separate make-weights shall be used for the tests for relaxation and felting dimensional changes.

9.3.3 Ensure that the temperature of the liquor plus load is 40 ± 2°C at the beginning of the test.

9.3.4 Subject the specimens and make-weights to agitation in the machine (*see* **6.1**) for a period of 30 to 60 minutes as agreed between the parties concerned.

9.3.5 Remove the specimens by folding the corners of each to the centre in such a way that the whole specimen can be supported in hand.

9.3.6 Hydroextract the specimens using the procedure described in **9.2.6**.

9.3.7 Dry each specimen using the procedure described in **9.2.7**.

9.3.8 Condition the specimens using the procedure described in **9.1.1**.

9.3.9 Measure the specimen's using the procedure described in **9.1.2**.

10 CALCULATION AND EXPRESSION OF RESULTS

10.1 Calculate the mean initial (I), relaxed (R), and felted (F) measurements taking:

a) three measurements in each direction for fabrics and garments other than socks and stockings; and

b) two length measurements for socks and stockings, one in leg and the other in foot.

10.2 Determine the linear dimensional change as follows:

$$\text{Relaxation dimensional change, percent} = \frac{R - I}{I} \times 100$$

$$\text{Felting dimensional change, percent} = \frac{F - R}{R} \times 100$$

$$\text{Total dimensional change, percent} = \frac{F - I}{I} \times 100$$

Indicate a decrease in dimension by a minus sign (–) and an increase in dimension by a plus sign (+).

10.3 Determine the area dimensional as follows :

$$\text{Area dimensional change, percent} = D_w + D_L - \frac{D_w \times D_L}{100}$$

where

D_w = mean dimensional change, percent, in width, and

D_L = mean dimensional change, percent, in length.

11 TEST REPORT

The test report shall state the following:

a) A statement that the test was conducted in accordance with this test method;

b) Type of apparatus used (*see* **6.1**);

c) Load to liquor ratio and time of felting stage;

d) For socks and stockings, the mean relaxation, felting and total dimensional changes in the length direction only to the nearest 0.1 percent; and

e) For fabrics and other garments, the mean relaxation, felting and total dimensional changes in respect of width, length and area to the nearest 0.1 percent.

ANNEX A

(*Clause* 6.1)

DETAILS OF WASHING APPARATUS

A-1 CUBEX INTERNATIONAL SHRINKAGE TESTING APPARATUS

A-1.1 The apparatus consists of a stainless steel hollow cube (368 mm × 368 mm × 368 mm inside measurement) having a capacity of 50 litres. The cube is insulated on five sides and the insulation is covered by a metal outer casing. In one face there is an opening fitted with a watertight hinged lid, through which the cube is loaded and discharged,. The cube rotates on spindles fixed at diagonally opposite corners, the apparatus being fitted with a reversible drive.

A-1.2 Mounted on the frame is a motor incorporating reduction gearing and an electrically controlled timing device which periodically reverses the motion of the cube. The aparatus is revolved at 60 rev/min for a given time, the direction of rotation being automatically reversed every 5 minutes with a 5-second pause between the reversing cycles. The timing device covers the range of 0 to 60 minutes and automatically cuts off at the end of the pre-set period.

A-1.3 At one corner of the cube is mounted a manually operable drain valve, through which liquid may escape when it is opened by the operator.

A-1.4 An expanded steel guard is provided and is so arranged that when it is lifted to allow the cube to be loaded or discharged, the driving power the cube is cut off. The whole assembly may be mounted on a rigid steel framework.

A-1.5 The load shall be made up of the test specimens plus make-weights not more than half the load of the specimens. The quantity of liquor used shall be sufficient to cover the load. Normally a load of 1 kg shall be used in 25 litres of the liquor.

A-2 WASH WHEEL

A-2.1 The wash wheel comprises a horizontal cylindrical machine with rotating cage and reversing mechanism. The cage should have a diameter between 400 mm and 600 mm and peripheral speed of 50 to 55 m/min. Other diameters may also be used provided that the rotational frequency is adjusted to give an equivalent peripheral speed.

A-2.2 Preferably 3 or 4 fins of lifters, about 80 mm wide, equally spaced around the interior of the cage and extending its full length, should be used. A single fin or 2 fins may also be used provided that equivalent results are obtained.

A-2.3 The cage shall turn at such a speed that the load is lifted by the fins and falls back into it (A peripheral speed of 54 m/min has been found satisfactory). The cage shall make 5 to 10 revolutions before its direction of rotation is reversed.

A-2.4 The machine shall be equipped with a heating facility using live steam, gas or electricity, and an outlet large enough to permit discharge of all liquid from the machine in less than 2 minutes.

A-2.5 A thermometer in a suitable well, or an equivalent equipment shall be provided to indicate the temperature of water within 1°C during washing and rinsing, and there shall be an outside water gauge to indicate the level of water in the wash wheel.

A-2.6 The mass of the load to be run in the machine shall be between 8 and 50 kg of air-dry fabric per cubic metre of cage space, including the volume of the fins. The load shall be made up of the test specimens plus make-weights not more than half the load of the specimens. The quantity of liquor used shall be sufficient to cover the load, the level being situated at height from one-seventy to one-third of the inside diameter of the cage.

DETERMINATION OF DIMENSIONAL CHANGES ON WASHING OF FABRICS WOVEN FROM RAYON AND SYNTHETIC FIBRES

(*Source* : **IS 1299 : 1984**)

The dimensions of fabrics woven from rayon and synthetic fibres are liable to change on soaking in water. Their dimensional instability is liable to be higher when washed with soap. As the goods made out of these materials are usually washed with soap, their dimensional change behaviour is of obvious interest to the consumer.

1 SCOPE

1.1 It prescribes a method for determination of dimensional changes on washing of fabrics woven from rayon and synthetic fibres or their mixtures.

1.2 The method is intended only for the assessment of dimensional changes undergone by woven fabrics subjected to single machanical washing. When it is desired to determine the amount of progressive dimensional changes, the test specimens should be washed repeatedly and the amount of dimensional changes in the washed specimens and the number of testing cycles to which the specimens have been subjected indicated clearly.

2 SAMPLING

2.1 Lot

The quantity of the fabric purporting to be of one definite type and quality, delivered to a buyer against one despatch note shall constitute a lot.

2.2 Samples for test shall be selected so as to be representative of the lot. Samples drawn in compliance with the material specification or as agreed to between the buyer and the seller shall be held to be representative of the lot.

3 TEST SPECIMENS

3.1 From the samples under test draw 3 test specimens, each of length 650 mm and of full width, taking care that:

a) the specimens are not drawn from within 1 m of either end of the piece,

b) no two specimens are drawn from the same piece, and

c) the specimens are cut and not torn from the piece.

3.2 The free edges of the specimens shall be sewn with a dimensionally stable thread, for example, polyester thread, using a chain stitch and stitch length of 2 to 3 mm.

4 CONDITIONING OF TEST SPECIMENS

4.1 Prior to test, the test specimens shall be conditioned to moisture equilibrium from dry side in the standard atmosphere at 65 ± 2 percent relative humidity and 27 ± 2°C temperature (*see* IS 6359:1971 'Method for conditioning of textiles', given in Section B-1/1).

4.2 When the test specimens have been left in such an atmosphere for 24 hours in such a way as to expose, as far as possible, all portions or the specimens to the atmosphere, they shall be deemed to have reached moisture equilibrium. However, in the case of fabrics which weigh more than 270 g/m^2, this period shall be 48 hours.

NOTE — It is preferable to store the newly finished fabrics for about a week before conditioning.

4.3 Atmospheric Conditions for Testing

The test shall be carried out in the standard atmosphere (*see* **4.1**).

5 APPARATUS

5.1 Cubex International Shrinkage Testing Apparatus or Wash Wheel or an Equivalent Machine

See Annex A.

5.2 Extractor

A laundry-type centrifugal extractor with perforated basket, capable of adjusting the moisture retention of the fabric to a range between 50 and 100 percent (m/m) based on the air-dry mass of the fabric.

NOTES

1 Any other apparatus that will give equivalent results without fabric distortion for example, rubber roll wringer which could pass the specimen through the rolls along a diagonal line without altering its dimensions may also be used.

2 Heavier fabrics of tight construction require a high moisture retention to ensure removal of wrinkles during pressing.

5.3 Pressing Equipment

A flat bed press capable of pressing a specimen of size 600 mm × 600 mm and of providing a minimum pressure of 3 kPa. The temperature of the press shall be 150 ± 15°C.

5.4 Marking Equipment

As specified in IS 10099:1982 'Methods for preparation, marking and measuring of fabric specimens and garments in tests for determination of dimensional change', given in Section C/1.

5.5 Make-Weights

The make-weights shall consist of fabric similar to that of the test specimens. Each make-weight shall be adjusted to a *p*H of 7 prior to use.

6 REAGENT

6.1 Soap Solution

Prepare a stock solution by dissolving 0.5 kg of soap in 4 litres of hot water. When cooled, this solution forms a thick jelly which may be used as required. From this stock solution, prepare a soap solution for the test containing 5 g/l of soap on dry mass basis.

Soap meeting the following composition (based upon dry mass) is satisfactory:

Free alkali calculated as Na_2CO_3, *Max*	0.3 percent
Free alkali calculated as NaOH, *Max*	0.1 percent
Combined fatty acids calculated as Na salt, *Min*	85 percent
Titre of mixed fatty acids prepared from the soap, *Max*	39°C
Iodine value of fatty acids, *Max*	50

NOTE — Information regarding availability of the soap of above composition may be had from BIS.

7 PREPARATION, MARKING AND MEASURING OF TEST SPECIMENS

7.1 The test specimens shall be prepared, marked and measured as specified in IS 10099:1982 'Methods for preparation, marking and measuring of fabric specimens and garments in tests for determination of dimensional change', given in Section C/1.

8 PROCEDURE

8.1 Initial Measurement

Expose the specimens to the standard atmosphere as specified in **4.1** until they reach moisture equilibrium (*see* **4.2**). Measure the distance between the centres of each of the pairs of marks to the nearest millimetre using the procedure described in IS 10099:1982 'Methods for preparation, marking and measuring of fabric specimens and garments in tests for determination of dimensional change', given in Section C/1.

8.2 Washing and Rinsing

8.2.1 Run water into the machine (*see* **5.1**) at the temperature such that the machine will heat the liquor to 50 °C within 10 minutes, maximum, and fill to the proper level for washing (*see* **A-1.5** or **A-2.6**) within 4 minutes.

8.2.2 Add a load of mass 1 kg, made up of the test specimens plus made-weights not more than half the load of the specimens.

8.2.3 Add sufficient soap (**6.1**) to give good running suds. If more than 5 g/l of soap is used, the amount and reasons for this shall be reported [*see* **11.1** (c)]. The temperature shall be maintained at not less than 45°C.

8.2.4 When the machine has run for 45 minutes, timed from the start of the test drain off the soap solution quickly and fill the machine with water to the proper level for rinsing. Raise the temperature to 50°C within 10 miunutes maximum.

8.2.5 When the machine has run for another 5 minutes, drain off the water, fill again and heat to 50°C as before.

8.2.6 At the end of the next 5 minutes, drain off the water quickly. Allow the machine to run without further additions for 5 minutes more. Stop the machine.

8.3 Extraction

Remove the specimens from the machine by folding the corners of each to the centre in such a way that the whole specimen can be supported in hand. Lay each specimen flat against the side of the perforated basket of the extractor to avoid streching during rotation and extract the excess water (**5.2**).

8.4 Pressing

Press each specimen taking care to ensure that it is smoothened. Without stretching, remove wrinkles before pressing. Continue this operation until sufficient moisture has been extracted from the fabric to ensure conditioning from the dry side.

8.5 Final Measurement

Allow the pressed specimen to cool, condition in the standard atmosphere and measure the distance between the centres of the markings to the nearest millimetre (*see* IS 10099 : 1982 'Methods for preparation, marking and measuring of fabric specimens and garments in tests for determination of dimensional change', given in Section C/1).

9 CALCULATION AND EXPRESSION OF RESULTS

9.1 Calculate the dimensional changes in the length and width directions separately by the following formula:

$$\text{Dimensional change, percent} = \frac{F - I}{I} \times 100$$

where

F = final measurement (*see* **8.5**), and

I = initial measurement (*see* **8.1**).

Express as percentages of the original value to the nearest 0.5 percent, using a minus sign (–) to indicate shrinkage and a plus sign (+) to indicate elongation. Calculate the mean value and the range of the dimensional change for each set of replicates.

9.2 Determine the area dimensional change as follows:

Area dimensional change, percent =

$$D_w + D_l - \frac{D_w \times D_l}{100}$$

where

D_w = mean dimensional change, percent in width; and

D_l = mean dimensional change, percent in length.

10 REPORT

10.1 The test report shall include the following particulars:

a) A statement that the test was conducted in accordance with this test method;

b) Type of apparatus used (*see* **5.1**);

c) Concentration of the soap solution used (state the reasons for using more than 5 g/l of soap when this amount is exceeded);

d) Number of testing cycles to which the specimens were subjected;

e) Dimensional changes in each specimen in the length and width directions and in area;

f) Mean dimensional changes in the replicates, in the length and width directions and in area; and

g) Range of individual dimensional change values.

ANNEX A

(*Clause* 5.1)

DETAILS OF WASHING APPARATUS

A-1 CUBEX INTERNATIONAL SHRINKAGE TESTING APPARATUS

A-1.1 The apparatus consists of a stainless steel hollow cube (368 mm × 368 mm × 368 mm inside measurement) having a capacity of 50 litres. The cube is insulated on five sides and the insulation is covered by a metal outer casing. In one face there is an opening fitted with a watertight hinged lid, through which the cube is loaded and discharged. The cube rotates on spindles fixed at diagonally opposite corners, the apparatus being fitted with a reversible drive.

A-1.2 Mounted on the frame is a motor incorporating reduction gearing and an electrically controlled timing device which periodically reverses the motion of the cube. The apparatus is revolved at 60 rev/min for given time, the direction of rotation being automatically reversed every 5 minutes with a 5-second pause between the reversing cycles. The timing device covers the range of 0 to 60 minutes and automatically cuts off at the end of the pre-set period.

A-1.3 At one corner of the cube is mounted a manually operable drain valve, through which liquid may escape when it is opened by the operator.

A-1.4 An expanded steel guard is provided and is so arranged that when it is lifted to allow the cube to be loaded or discharged, the driving power to the cube is cut off. The whole assembly may be mounted on a rigid steel framework.

A-1.5 The load shall be made up of the test specimens plus make weights not more than half the load of the specimens. The quantity of liquor used shall be sufficient to cover the load. Normally a load of 1 kg shall be used in 25 litres of the liquor.

A-2 WASH WHEEL

A-2.1 The wash wheel comprises horizontal cylindrical machine with rotating cage and reversing mechanism. The cage should have a diameter between 400 and 600 mm and peripheral speed of 50 to 55 m/min. Other diameters may also be used provided that the rotational frequency is adjusted to give an equivalent peripheral speed.

A-2.2 Preferably 3 or 4 fins or lifters, about 8 cm wide, equally spaced around the interior of the cage and extending its full length, should be used. A single fin or 2 fins may also be used provided that equivalent results are obtained.

A-2.3 The cage shall turn at such a speed that the load is lifted by the fins and falls back into it (A peripheral speed of 54 m/min has been found satisfactory). The cage shall make 5 to 10 revolutions before its direction of rotation is reversed.

A-2.4 The machine shall be equipped with a heating facility, using live steam, gas or electricity, and an outlet large enough to permit discharge of all liquid from the machine in less than 2 minutes.

A-2.5 A thermometer in a suitable well, or an equivalent equipment, shall be provided to indicate the temperature of water within 1°C during washing and rinsing, and there shall be an outside water gauge to indicate the level of water in the wash wheel.

A-2.6 The mass of the load to be run in the machine shall be between 8 and 50 kg of air-dry fabric per cubic metre of cage space, including the volume of the fins. The load shall be made up of the test specimens plus make-weights not more than half the load of the specimens. The quantity of liquor used shall be sufficient to cover the load, the level being situated at a height from one-seventh to one-third of the inside diameter of the cage.

DETERMINATION OF DIMENSIONAL CHANGES OF SILK FABRICS ON WASHING

(*Source* : **IS 3561 : 1989**)

Merely on soaking in water the dimensions of fabrics woven from silk are liable to change. Their dimensional instability is liable to be higher when washed with soap. As fabrics made out of silk are washed with mild soap, their dimensional stability is of obvious interest to the consumer.

1 SCOPE

1.1 It prescribes a method for determination of dimensional changes on washing of natural silk fabrics.

1.2 The method is intended only for the assessment of dimensional changes undergone by fabrics subjected to a single washing treatment. When it is desired to determine the amount of progressive dimensional changes, the test specimens should be washed repeatedly and the amount of dimensional changes of the washed specimens and the number of washing cycles to which the specimen has been subjected, be indicated clearly in the report.

2 PRINCIPLE

The specimens, after conditioning, is measured, washed, dried under prescribed conditions, reconditioned and remeasured. The dimensional changes obtained are calculated from the means of the original and final dimensions in the length ways and/or widthways direction.

3 SAMPLING

Sample from the lot shall be drawn so as to be representative of the lot. Sample drawn in accordance with the relevant material specification or as agreed to between the buyer and the seller shall be held to be representative of the lot.

4 APPARATUS

4.1 Water Tight Tray or Container

Approximately 100 ml deep and of sufficient area to contain the specimen horizontally without folding. It shall be provided with a glass plate for covering and with suitable draining arrangement.

4.2 Steel Rule, graduated in mm.

4.3 Means of Marking Reference Points, as specified in 4.3 of IS 10099 : 1982 'Methods for preparation, marking and measuring of fabric specimens and garments in tests for determination of dimensional change' given in Section C/1.

4.4 Two Pieces of Plate Glass, each measuring at least 600 mm × 600 mm.

5 REAGENTS

5.1 Quality of Reagents

Unless otherwise specified pure chemicals and distilled water shall be used wherever the use of water as a reagent is intended.

NOTE — 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the test results.

5.2 Soap Solution

Containing 5 g of soap per litre of the composition as specified in Annex A.

6 ATMOSPHERE FOR CONDITIONING AND TESTING

6.1 Prior to test, the test specimens shall be conditioned to mositure equilibrium from the dry side in a standard atmosphere at 65 ± 2 percent relative humidity and 27 ± 2°C temperature (*see* IS 6359 : 1971 'Method of conditioning of textiles', given in Section B-1/1).

6.2 When the test specimens have been left in such an atmosphere for 24 hours in such a way as to expose, as far as possible, all portions of the specimens to the atmosphere, they shall be deemed to have reached moisture equilibrium. However, in case of fabrics which weigh more than 270 g/m^2, this period shall be 48 hours.

NOTE — It is preferable to store the newly finished fabrics for about a week before conditioning.

6.3 The testing shall be carried out in the standard atmosphere (*see* **6.2**).

7 TEST SPECIMENS

Draw at least one test specimen from each piece of wide fabrics measuring not less than 500 mm × 500 mm with edges parallel to the length and width of fabric and at least three specimens from each piece of narrow fabrics measuring 500 mm in length and of full width. Do not take any specimen within 1 m of either end of the piece. In case of wide fabrics, do not take specimens with selvedges. For knitted fabrics, make up the specimens in double thickness, sewing the free edges together with dimensionally stable thread. When fabrics with fancy weave structures are being tested, ensure as far as possible that exact number of repeats are taken in each test specimen.

NOTE — The specimen should be cut and not torn from the fabric.

8 PROCEDURE

8.1 Marking and Measuring of Test Specimens before Washing

Mark and measure the distance between reference points in the test specimens previously conditioned in the standard atmosphere (*see* **6.2**) as prescribed in IS 10099 : 1982. 'Methods for preparation, marking and measuring of fabric specimens and garments in tests for determination of dimensional change', given in Section C/1.

8.2 Washing of Test Specimens

8.2.1 Lay one test specimen flat after removing all creases and wrinkles by hand for one hour in the watertight tray containing 5 g/l of soap solution at 50°C. Ensure that the depth of liquid above the specimen is at least 25 mm. If necessary, keep the specimen submerged, for example, by use of small weight-pieces, ensuring that these are as small as possible.

8.2.2 After 1 hour, pour off the liquid and wash the specimen first with water at 50°C for 20 minutes and then with cold water for 5 minutes while kept flat Remove the specimen without distortion from the tray and place it flat on a towel. Ensure that the specimen is not stretched during handling. The most convenient method is to fold the corners to the centre so that the whole specimen is supported when lifted on to the towel. Remove excess moisture by lightly pressing another towel on top of the specimen.

8.2.3 Lay the specimen on a smooth flat surface and allow it to dry at room temperature. Condition the specimen in the standard atmosphere (*see* **6.1**) to moisture equilibrium from the dry side and remeasure the distances between corresponding reference points to the nearest mm as prescribed in **8.1**.

8.3 Repeat the procedure from **8.1** to **8.2.3** with the remaining test specimens.

9 CALCULATION AND EXPRESSION OF RESULTS

9.1 Calculate the mean of the original dimensions and the mean of the final dimensions for each test specimen in each direction separately to the nearest millimetre. Calculate separately the percentage dimensional change for each specimen in each direction (lengthways and widthways) by the formula:

$$\text{Dimensional change, percent} = \frac{100(b-a)}{a}$$

where

a — mean original dimension before treatment for each test specimen, and

b - mean final dimension after treatment for each test specimen.

9.2 Calculate the mean of the dimensional changes of all the specimens, separately in each direction.

9.3 Express the mean dimensional change percent in each direction to the nearest 0.1 percent.

10 REPORT

The report shall include the following information:

a) Whether the specimens were from wide of narrow fabrics and the number of specimens tested from each piece in the test sample;

b) The mean dimensional change, percent, in the lengthways and widthways directions for wide fabrics, and in the lengthways directions for narrow fabrics; and

c) Indicate a decrease in dimension by a minus sign and an increase by a plus sign.

ANNEX A

(*Clause* 5.2)

COMPOSITION OF SOAP

a)	Soap shall be free from optical brightening agents	
b)	Moisture regain, percent, *Max*	4
c)	Titre of fatty acids, °C, *Max*	25
d)	Total fatty matter, percent by mass, *Min*	80
e)	Rosin acids, percent by mass of total fatty matter, *Max*	3.0
f)	Unsaponified fatty matter, percent by mass, *Max*	0.5
g)	Free caustic alkali, percent by mass, *Max*	0.05
h)	Matter insoluble in alcohol, percent by mass, *Max*	2.0
j)	Glycerol percent by mass, *Max*	1.5
k)	Hexabromide test (on fatty acids)	Negative

DETERMINATION OF ABSORBENCY OF ABSORBENT TEXTILE MATERIALS

(*Source* : IS 2369 : 1967)

Absorbent textile materials, such as cotton gauze and cotton wool, are used mostly for surgical purposes. A cotton material of definite absorbency is necessary for use in surgical and other purposes. A textile material, whose absorbency in terms of seconds is less than 10, is considered as highly absorbent material. it is hoped that the revised standard would be helpful in determining the absorbency of absorbent textile materials.

1 SCOPE

This standard prescribes a method for determination of absorbency of absorbent textile materials, such as cotton gauze and cotton wool.

2 PRINCIPLE

The test specimen of specific area or specific volume is placed on the surface of water. The time taken by the specimen to absorb water and sink in it completely is a measure of the absorbency of the test specimen. The shorter the time taken by the specimen to sink in water completely, the greater is its absorbency.

3 SAMPLING

3.1 Lot

The quantity of rolls or bundles of absorbent material (such as cotton gauze and cotton wool) delivered to the buyer against a despatch note shall constitute the lot.

3.2 Unless otherwise agreed to between the buyer and the seller the number of rolls or bundles to be selected at random from the lot shall be as given below:

Lot size (1)	*Sample Size* (2)
Up to 100	4
101 " 150	5
151 " 300	7
301 " 500	10

3.3 The rolls or bundles selected according to **3.2** shall constitute the test sample.

4 CONDITIONING OF TEST SPECIMENS AND ATMOSPHERIC CONDITIONS FOR TESTING

4.1 Conditioning for Test Specimens

Prior to test, the test specimens shall preferably be conditioned to moisture equilibrium in a standard atmosphere at 65 ± 2 percent relative humidity and 27 ± 2°C temperature (*see* Section B-1/1).

4.1.1 When the test specimens have been left in such an atmosphere for 24 hours in such a way as to expose, as far as possible, all portions of the specimens to the atmosphere, they shall be deemed to have reached moisture equilibrium.

4.2 Atmospheric Conditions for Testing

The test shall preferably be carried out in the standard atmospheric conditions (*see* **4.1**).

5 APPARATUS

5.1 Wide-Bore Glass Tube, open as both ends (*see* Fig. 1).

5.2 Glass Plunger, solid or closed at the bottom (*see* Fig. 1).

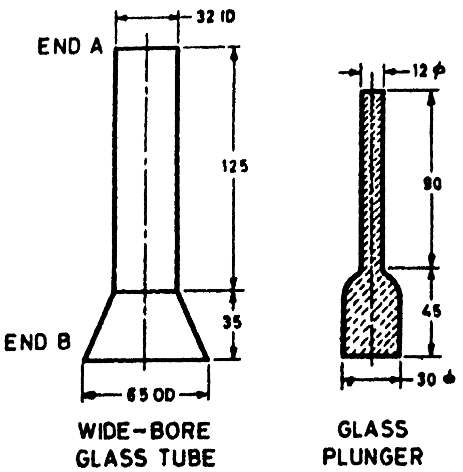
5.3 Glass Trough, of suitable size, preferably 20 cm × 15 cm × 50 cm.

5.4 Retort Stand, with a clamp.

5.5 Stop-Watch, reading correct to 0.1 second.

5.6 Two Glass Plates, 10 cm × 10 cm and 0.75 cm thickness.

5.7 A Pair or Forceps



All dimensions in millimetres

FIG. 1 WIDE-BORE GLASS TUBE (WITH FUNNEL END *B*) AND GLASS PLUNGER

6 REAGENTS

Distilled Water, maintained at 27 ± 2°C.

7 PROCEDURE

7.1 Method I — For Cotton Gauze Like Material

Exposing specific area to water.

7.1.1 From each roll or bundle in the sample, draw 5 test specimens each from a single layer and weighing 1 g.

7.1.2 Take one test specimen. Fold it to a square of 5 cm × 5 cm. Place it between the glass plates. Place 1 kg weight on the glass plate for 10 minutes. Remove the weight and the top glass plate. Place the test specimen gently on the surface of water with a pair of forceps. Start the stop-watch when the test specimen touches the surface of water. Stop the stop-watch when the test specimen disappears under the surface of water. Note the time taken.

7.1.3 Repeat the procedure as given in **7.1.2** with the remaining test speciemens.

7.1.4 Calculate the average time, in seconds, taken by the test specimens to sink in water.

7.2 Method II - For Cotton Wool Like Material

Exposing specific volume to water.

7.2.1 From each roll or bundle in the test sample, draw 5 test specimens each weighing 1 g.

7.2.2 Take one test specimen. Hold the wide-bore glass tube vertical on a flat surface with the funnel end *B* at the top. Transfer the test specimen to the tube. Insert the plunger and gently compress the test specimen to a volume of 20 ml.

NOTE - The tube may be graduated. If not the test specimen may be compressed to a length of 25 mm in the tube which gives a volume of 20 ml.

7.2.3 Pour the distilled water in the glass trough so that the level of water is 70 mm below the top of the trough.

NOTE — A clearance of 70 mm from the top is necessary to prevent or minimize the air draught acting on the test specimen when it is dropped on the surface of the water.

7.2.4 Fix the glass tube with the test specimen inside the tube on the stand in such a way that the funnel end *B* is 5 mm above the surface of water in the trough. Insert the plunger from the end *A* and push slowly the test specimen on the surface of the water. Start the stop-watch when the test specimen touches the surface of water. Stop the stop-watch when the test specimen just disappears under the surface of water. Note the time taken.

NOTE — The test specimen should disappear under the surface of the water when completely saturated with water.

7.2.5 Repeat the procedure given as in **7.2.2** to **7.2.4** with the remaining test specimens.

7.2.6 Calculate the average time, in seconds, taken by the test specimen to sink in water.

8 REPORT

Report the method followed and the average time taken (*see* **7.1.4** or **7.2.6**) as the absorbency of the absorbent material in the lot in terms of seconds.

DETERMINATION OF WETTABILITY OF COTTON FABRICS

(*Source* : **IS 2349:1963**)

In the cotton textile industry the fabrics undergo treatment of scouring prior to bleaching and other finishing treatments. By scouring treatment the cotton material is made more absorbent. Wettability is a very important property of all textile materials. Bleaching, dyeing, and finishing of textiles are dependent among others on the wettability of the material. It is expected that the method of test prescribed in this standard would be of use for determining the wettability of cotton textile materials.

1 SCOPE

It prescribes a method for the determination of wettability of cotton fabrics. This method is also applicable for assessing the efficiency of scouring.

2 PRINCIPLE

A drop of water is allowed to fall on the test specimen. A lamp is suitably placed so that the image of the lamp is seen on the drop. The time taken for the image of the lamp to just disappear at the edge of the drop is noted. This time is a measure of the wettability of the sample under test.

NOTE — The longer the time taken, the lower is the wettability

3 SAMPLING

3.1 Sample to determine wettability of a lot of the material shall be selected so as to be representative of the lot.

3.2 Sample drawn in accordance with an agreement between the buyer and the seller to determine the wettability of a lot of the material shall be held to be representative of the lot.

3.3 In case of dispute as to whether the material in a lot conforms to the standard or not and there being no agreed method of drawing its representative sample, the sample selected to represent the lot shall consist of fabric from bales constituting the early, middle and late parts of the lot in order of time of delivery, or in the case of single delivery, in order of serial numbers of bales. The fabric selected shall be not less than 1 percent nor more than 10 percent of the lot by weight and shall be selected from bales constituting not less than 10 percent nor more than 50 percent of the lot. The fabric so drawn shall constitute the test sample.

4 ATMOSPHERIC CONDITIONS FOR TESTING

4.1 Unless otherwise provided for in an agreement between the buyer and the seller, all tests shall be carried in a standard atmosphere at 65 ± 2 percent relative humidity and 27 ± 2°C temperature or within a period of 5 minutes of the removal of the test spcimen from the standard atmosphere.

4.2 The test shall be carried out in standard atmosphere (*see* **4.1**).

5 CONDITIONING OF TEST SPECIMENS

5.1 Prior to evaluation, the test sample (or the test specimens drawn therefrom) shall be conditioned to moisture equilibrium (*see* **4.1**), unless otherwise provided for in an agreement between the buyer and the seller.

6 PREPARATION OF TEST SPECIMENS

6.1 From the test sample drawn as in **3.2** and **3.3**, draw at random a 20 cm × 20 cm test specimen such that at least five test specimens are taken. Treat these test specimens with distilled water at 30°C, with a material to liquor ratio of 1 : 50 for 30 minutes. Then remove the moisture present in the test specimens by pressing them between folds of filter paper and dry them at room temperature.

6.2 Take one test specimen treated as in **6.1**, and mark on it, preferably in the middle, by means of marking pencil a square measuring 10 cm × 10 cm. Subdivide the square into 25 small squares, each measuring 2 cm × 2 cm.

7 APPARATUS AND REAGENTS

7.1 An apparatus consisting of a base on which are fixed:

a) an arm which carries :

  1) a boss holding a small burette which is provided preferably with a metal edge, that is, a tip of external diameter 1.2 mm; and

  2) a housing containing an electrical lamp.

b) a viewing ring which is adjustable for height corresponding to the length of the specimen to be examined.

7.2 Wooden Embroidery Frame

15 cm in diameter.

7.3 Stop-Watch

Reading correct to one-tenth of a second.

NOTE — A reciprocal time scale reading up to two revolutions superimposed on the ordinary scale is very convenient

7.4 Distilled Water

8 PROCEDURE

8.1 Mount the test specimen on the embroidery frame so as to have a taut surface.

8.2 Switch on the electric lamp of the apparatus. Fill the burette with distilled water. Place the test specimen mounted on the frame on the base of the apparatus. Adjust the height of the burette such that the surface of the cloth is just two drops beneath the edge of the burette, and that the drop falls on one of the squares.

8.3 Allow a drop to fall on the specimen and, at the same time, start the stop-watch. Observe the image of the lamp on the face of the drop through the viewing ring. When the image disappears at the edge of the drop, stop the stop-watch. From the two readings observed, calculate the time, in seconds, taken for the image of the lamp to disappear at the edge of the drop.

NOTE — The end-point is determined by placing the viewing ring between the observer and a source of light, such as a window, at such an angle that the specular reflection of the light from the surface of the flattened drop can be plainly seen. As the drop is gradually absorbed, the area of this tiny mirror dimnishes and finally vanished entirely leaving only a dull wet spot behind. The stop-watch is stopped at this moment.

8.4 Repeat the procedure prescribed in **8.3** with the remaining squares in the specimen.

8.5 Calculate the average of all the values obtained as in **8.3** and **8.4**.

8.6 Repeat the procedure prescribed in **8.1** to **8.5** with the remaining test specimens.

8.7 Calculate the average of all values obtained as in **8.5** and **8.6**.

9 REPORT

Report the average value obtained (*see* **8.7**) as the wettability of the fabric in the lot in terms of seconds.

DETERMINATION OF WATER REPELLENCY OF FABRICS BY CONE TEST

(*Source* : IS 7941 : 1976)

Water passes through water-resistant fabrics by:

a) penetration of water through their interstices under its own or applied pressure (the resistance offered by fabrics to this action is influenced mainly by their construction or structure),

b) Wetting of one side of the fabrics followed by capillary action; this brings the water to the other side and wets it (the resistance offered by fabrics to this action is influenced mainly by their water-repellency), and

c) combination of (a) and (b).

A number of test methods has been developed for testing waterproofness, water repellency and water resistance of fabrics like spray test, hydro-static head test, Bundesmann test, cone test, etc. All these test methods are prevalent in industry and trade. However, the use of a particular test depends upon the type of fabric under test and its end uses. So far no correlation has been established between the results of different test methods and hence their results are not comparable.

The prescribed cone test is a fairly simple test for assessing the resistance of fabrics to wetting by water. According to this method the water resistance of fabrics is assessed on the basis of (a) the degree of wetting of outer surface, and (b) the amount of water leakage through the fabric cone when water is kept standing for a fixed time.

1 SCOPE

1.1 It prescribes a method for determining the water repellency of fabrics (permeable as well as non-permeable to air) by cone test.

1.1.1 This test shall be generally applicable for testing heavier types of proofed fabrics used as covers for wagons, shelters, etc, where pools of water may collect during use due to depressions formed by the uneven level of the cover.

2 PRINCIPLE

Specimen of the fabric is folded to form a cone and kept in a wire cone kept in glass funnel. A specified amount of water is poured into the cone and left to stand for a fixed time. The assessment is made on the basis of:

a) wetting of the outer exposed surface, and

b) amount of water leaked out of the cone.

3 SAMPLING

Samples shall be so drawn as to be representative of the lot. Samples drawn in compliance with the procedure laid down in the material specification or as agreed to between the buyer and the seller shall be taken as representative of the lot. In case of cotton fabrics, reference to IS 5463:1969 'Method for sampling of cotton fabrics for chemical tests', given in section A-1/3 shall be made.

4 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

4.1 The test specimens shall be conditioned in accordance with IS 6359 : 1971 'Method for conditioning of textiles', given in Section B-1/1 except in case of fabrics heavier than 270 g/m^2 for which the minimum conditioning period shall be 48 hours.

4.2 The tests shall be carried out in standard atmosphere.

5 PREPARATION OF TEST SPECIMEN

Take a specimen of 30 cm × 30 cm from the conditioned test sample and fold it in the form of a cone without creasing the folds. Prepare at least 3 test specimens.

6 APPARATUS

6.1 **Glass or Metal Funnel**, of 60° angle and of sufficient size.

6.2 Wire Cone, A typical sketch of the wire cone is given in Fig. 1.

6.3 Glass Rod

6.4 Conical Flask, for collecting water under the glass funnel.

6.5 A Stand, for holding the cone assembly.

6.6 Measuring Flask

6.7 Water

Distilled water maintained at a temperature of the testing atmosphere (*see* 4.2).

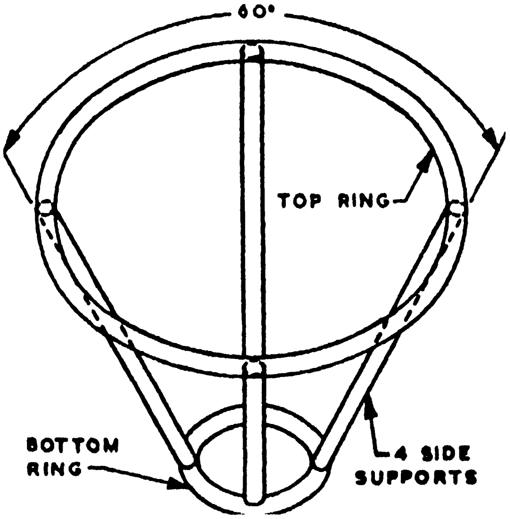


FIG. 1 A TYPICAL WIRE CONE

7 PROCEDURE

7.1 Take a test specimen and prepare a fabric cone (*see* 5), place it in the wire cone and in turn place them (fabric cone in wire cone) in the glass (on metal) funnel. Mount the assembly on the stand (*see* Fig. 2). Place a conical flask below the glass funnel. Pour slowly 400 ml of water from the sides with the help of a glass rod and let it stand for 18 hours. At the end of the test period remove the water container from below and also pour out the water from the cone assembly immediately.

7.2 Determine the amount of water (in millilitres) collected in the container and also visually assess the area of wetting of the outer surface of the fabric cone coming into contact with the surface of the wire cone (that is, ignoring the presence of water within the folds of the fabric cone).

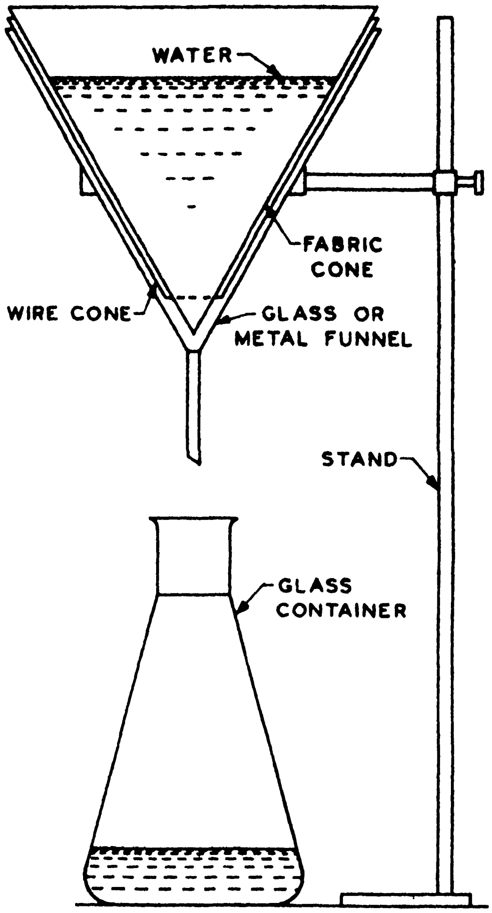


FIG. 2 ASSEMBLY OF APPARATUS

7.3 Repeat the test with the remaining test specimens.

8 CRITERIA OF ASSESSMENT

Assessment of the effectiveness of profness of the sample shall be made on the basis of limits laid down in the material specification for:

a) amount of penetrated water collected in millilitres (*see* 7.2), and
b) amount of wetting of outer surface (*see* 7.2).

9 REPORT

The report shall indicate the following information:

a) Type of fabric,
b) Number of test specimens tested,
c) Assessment rating:
    1) amount of penetrated water collected in millilitres; and
    2) amount of wetting of outer surface.

DETERMINATION OF WATER REPELLENCY OF FABRICS BY WATER SPRAY TEST

(*Source* : IS 390:1975)

The spray test prescribed in this test method is a fairly simple test for assessing the resistance of fabrics to wetting by water (water repellency). According to this test method the water repellency of fabrics is assessed on the basis of the area of the specimen wetted by a spray of water.

1 SCOPE

It prescribes a method for determining the water repellency of fabrics (permeable as well as non-permeable to air) on the basis of the wetted area of the specimen by spray test.

2 SAMPLING

2.1 Samples drawn in compliance with the procedure laid down in the material specification or as agreed to between the buyer and the seller shall be taken as representative of the lot. In case of cotton fabrics reference to IS 3919:1966 'Method for sampling cotton fabrics for determination of physical characteristics' as given in Section A-1/2 shall be made.

2.2 At least four test specimens, each 230 mm in diameter, shall be drawn at random from each individual piece in the test sample.

3 CONDITIONING AND TESTING ATMOSPHERE

3.1 The test specimen shall be conditioned in accordance with IS 6359:1971 'Method of conditioning of textiles', given in Section B-1/1 except in case of fabrics heavier than 270 g/m^2 for which the minimum conditioning period shall be 48 hours.

3.2 The tests shall be preferably carried out in standard atmosphere. In case it is not possible to carry out the test in standard atmosphere, the specimens shall be conditioned as provided for in **3.1** and tested in prevailing atmosphere immediately thereafter.

4 APPARATUS

4.1 For the purpose of this test, the following apparatus shall be assembled as given in Fig. 1.

4.1.1 *A Spray Device*

It shall be so constructed that 250 ml of water should take 25 to 30 seconds to spray on the specimen and the spray should cover an area approximately 150 mm in diameter in a horizontal plane 150 mm below the perforated spray nozzle.

4.1.2 *Stand*

For holding spray device and the specimen holder. The specimen shall be at an angle of 45° to the vertical central line of the funnel and the spray device shall also be vertical.

4.1.3 *Specimen Holder*

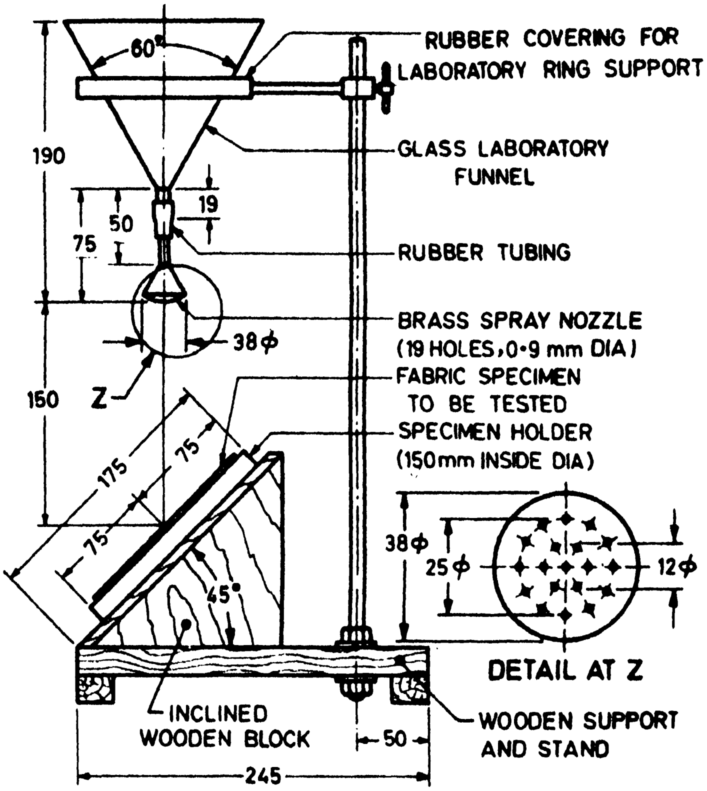
A thin circular frame of 150 mm inside diameter closely fitting in an outer circular frame (similar in construction to hoops used for embroidery).

5 PROCEDURE

5.1 Mount the specimen in the specimen holder, face upward, taking care to keep the former taut. Place the specimen so mounted under the spray nozzle on the support provided in the stand for this purpose in such a way that the warp threads are approximately parallel to the direction of flow of water. Pour from the sides quickly into the funnel 250 ml of distilled water at 27 ± 2°C and allow it to spray on the specimen (In order to make the degree of wetting distinctly visible, such colouring matter may be added to water, that does not affect the surface tension of water).

NOTE — Where it is not possible to distinguish between the 'face' and the 'back', surface of the specimen mounted upwards shall be held to be its face.

5.2 Remove the specimen holder from the stand when the spraying has ceased. Hold the specimen holder so that, the lowest point of the holder during spraying is in the lowest position, the holder is slightly inclined to the vertical, and the face of the specimen leans slightly forward. Tap the lowest point of the holder 3 times in succession against a horizontal surface.



RUBBER COVERING FOR LABORATORY RING SUPPORT
GLASS LABORATORY FUNNEL
RUBBER TUBING
BRASS SPRAY NOZZLE (19 HOLES, 0·9 mm DIA)
FABRIC SPECIMEN TO BE TESTED
SPECIMEN HOLDER (150 mm INSIDE DIA)
DETAIL AT Z
WOODEN SUPPORT AND STAND
INCLINED WOODEN BLOCK
60°
190
19
50
75
38ϕ
150
Z
175
75
75
45°
38ϕ
25ϕ
12ϕ
50
245

All dimensions in millimetres.

FIG. 1 APPARATUS FOR SPRAY TEST

6 METHOD OF RATING

6.1 Immediately after the tappings compare, under reflected light, the wetting of the face of the specimen with the photographic standard spray test ratings (*see* Fig. 2). Assign the specimen under test the standard spray test rating to which its wetting best approximates.

6.2 Repeat the test with the remaining test specimens and rate them.

6.3 The average standard rating number obtained by evaluating all the test specimens, rounded off to the nearest standard rating numbers, shall be reported as the rating number of the sample.

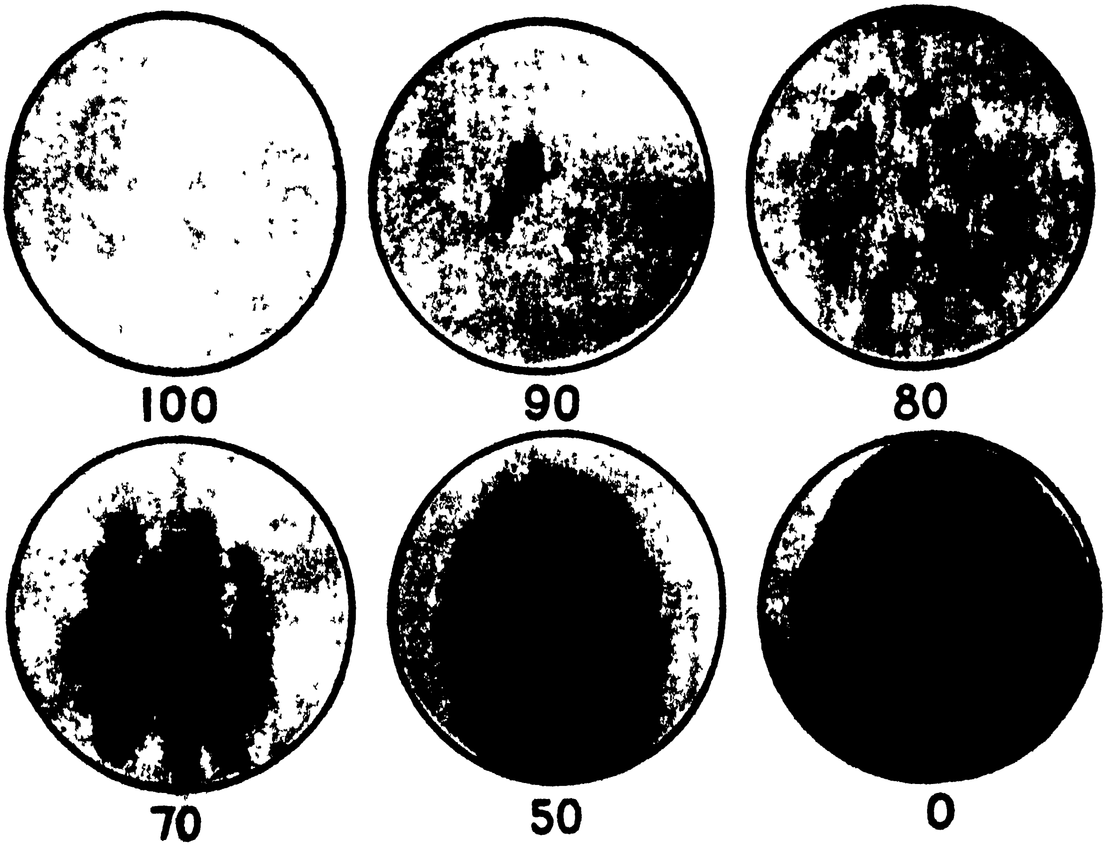
7 REPORT

Report shall include the following information:

a) Type of fabric,

b) Number of test specimens tested, and

c) Rating number.



100– No sticking or wetting of the face

90– Slight random sticking or wetting of the face

80–Wetting of the face at spray points

70– Partial wetting of the whole of the face

50–Practically complete wetting of the whole of the face

0–Complete wetting of the whole of the face

(COLOURED WATER USED FOR PHOTOGRAPHIC EFFECT)

FIG 2 STANDARD SPRAY TEST RATINGS

DETERMINATION OF WATER ABSORPTION AND PENETRATION OF FABRICS USING BUNDESMANN TYPE APPARATUS

(*Source* : IS 392 : 1989)

The work carried out with the Bundesmann apparatus has produced evidence of unidentified variables. The reproducibility of the method is such that although variability within tests or a given apparatus may be reduced to a satisfactory level, the variability between tests on different apparatus may be large. However, for testing water-repellency and water resistance of textile fabrics, the use of the Bundesmann apparatus is well established since the method fulfils the need where quality control testing within a laboratory is concerned.

The Bundesmann test is used to assess the behaviour of water resistant fabrics when exposed to heavy rain. To assess the efficiency of proofing of water resistant fabrics permeable to air, the quantity of water absorbed by the specimen and as a result of exposure to artifical rainfall for the period of test are measured separately, and the data considered collectively.

1 SCOPE

1.1 It prescribes a method for determination of water repellency, resistance to wetting (in term of water absorbed) and resistance to penetration by water in terms of water penetrated) of fabrics by the Bundesmann type apparatus.

1.1.1 It is primarily applicable to woven or non-woven water repellent fabrics that are permeable to air.

2 PRINCIPLE

Four specimens of the fabrics under test are simultaneously exposed to a simulated heavy rain shower of controlled intensity, while the specimen as a whole is flexed and the under surface subjected to the rubbing action. The water absorbed by the specimens is determined after the test is over which is the measure for resistance to wetting. The penetrated water collected in cups is the measure for resistance to penetration by water.

3 SAMPLING

Sample shall be drawn so as to be representative of the lot. Sample drawn in compliance with the procedure laid down in the material specification or as agreed to between the buyer and the seller shall be taken as representative of the lot. In case of cotton fabrics, reference to Section A-1/2 shall be made.

4 PREPARATION OF TEST SPECIMENS

4.1 Condition the test sample as specified in **5.1**. From each individual piece in the test sample, cut out four circular test specimens without any crease, each of 140 mm diameter with a circular dye such that each is taken from different location spaced at least 100 mm away from the edge of the fabric sample being tested. The specimens shall not be folded, ironed or treated otherwise during the interval between the drawing of the sample and testing, except for conditioning. If possible the specimens should not be taken directly from the ends of the material, since experience has shown that the area density (for example, structure) and the finishing may be different to that of the majority of the fabric.

NOTE — The cutting of specimens by means of a circular cutting die and press is facilitated if squares 150 mm × 150 mm are first cut from the fabric sample.

5 CONDITIONING AND TESTING ATMOSPHERE

5.1 The test specimens shall be conditioned in the standard atmsophere at 65 ± 2 percent relative humidity and 27 ± 2°C temperature at least for 24 hours (*see* IS 6359:1971 'Method for conditioning of textiles' given in Section B-1/1). In case of fabric specimens heavier than 270 g/m^2, the minimum conditioning period shall be 48 hours.

5.2 The tests shall be preferably carried out in standard atmosphere (*see* **5.1**). In case it is not possible to carry out the test in standard atmosphere, the specimens shall be conditioned as provided for in **5.1** and tested in prevailing atmosphere within 15 minutes of their removal from the standard atmosphere (*see* **5.1**).

6 APPARATUS

6.1 The apparatus shall be of the continuous-shower type (*see* Annex A for details).

6.2 Suitable Means for Cutting Specimens of 140 mm Diameter

A circular die shall be used with a press or a template and scissors.

6.3 A Mechanical Shaker, conforming to requirements given in A-5.

6.4 A Stop-Watch or Stop Clock

6.5 Airtight Containers

These containers shall be of known mass and of such a shape and size that the specimen may be inserted without being creased before exposure to the shower.

6.6 A Balance, sensitive to 0.01 g.

7 PROCEDURE

7.1 Determine the mass of each conditioned specimen in a tared airtight container to the nearest 0.01 g. Set the shower working. The water supply used for the test shall conform to the following requirements and any blocking to the drop-forming system (by foreign matter, etc) must be avoided. Use of a filter (containing porcelain, Kieselghur candles) on water feeding is recommended.

a) *Temperature*
The temperature of water in the shower tank shall be 27 ± 2°C. A thermostatically controlled domestic electric water-heater may be used to maintain the required temperature.

b) *p*H
The *p*H of the water shall be 7.0 ± 1.0.

NOTE — If required, *p*H may be adjusted by passage of water through suitable ion-exchange resins, or distilled water may be used.

c) *Rate of Flow*
The rate of flow of water into a cup shall be 65 ± 3 ml/min per cup.

7.1.1 Check the rate of flow at least once every 60 min of continuous operation as follows:

Place the cup assembly in position inside the apparatus, with the cups drained and the draincocks closed. Switch on the motor. Swing away the tray to allow the drops to fall on the cups, simultaneously starting the stop watch or stop clock. Expose the cups for 1 min, swing the tray into position to intercept the shower, stop the motor and remove the cup assembly to its stand. Dry the outside of the draincocks. Drain each cup through the draincock into a 100 ml graduated cylinder and check that the required rate of flow has been obtained.

7.2 Before mounting the test specimens, dry all parts of the cups, wipers and clamps that may come in contact with the specimens. Remove any water in the exit tubes. Do not dry the insides of the cups which should be in drained condition at the start of each test. Close the draincocks.

7.3 Mount the specimens with the wiper mechanism in the depressed position. Lay the specimens over the cups and apply the size of clamping ring that will expose an area of specimen with diameter as close as possible to 100 mm. The specimens must be in continuous contact with the rims of cups without folds or other irregularity. Lock the clamping rings in position with the spring-operated clamps.

NOTE — It is important to note that the clamps should be so designed that according to its thickness, the test specimen is not exposed where it is mounted over a hard backing (for example, the outside of the cup rim) since the impact of the shower on fabric so mounted may lead to an increase in penetration through the test specimen.

7.4 Release the wiper arms, if necessary and place the cup assembly in position inside the apparatus. Switch on the motor. Swing away the tray to allow drops to fall on the specimens, simultaneously starting the stop-watch or stop-clock. Expose the specimens to the shower for 10 min unless otherwise agreed between the buyer and the seller.

7.5 At the end of the test period, swing the tray into position to intercept the shower, stop the motor and remove the cup assembly to its stand. Immediately unclamp each specimen from the cups and remove the loosely attached water by gripping each specimen without folding or creasing it in the clip of the mechanical shaker and rotating the handle so that the specimen receives 10 shakes. Transfer each specimen to an airtight container immediately after the shaking is completed.

7.6 Determine the mass of each loaded container to the nearest 0.01 g.

7.7 Dry the outside of the closed draincocks. Individually drain each cup into a measuring cylinder and measure to the nearest millilitre the volume of water collected from each cup separately.

7.8 Expression of Results

Calculate the absorption and penetration of water as follows.

7.8.1 *Absorption*

Calculate the percentage of absorption of water by the following formula:

$$A = \frac{(M_2 - M_1) \times 100 \times 2}{M_1}$$

where

A = percentage of absorption of water,

M_1 = mass of the test specimen before test in g, and

M_2 = mass of the test specimen after testing in g.

NOTE — Since the total area of the test specimen is double the exposed area, it is necessary to multiply the absorption figure by two to get the correct results.

7.8.2 *Penetration*

The volume of water in millilitres, collected in each cup, shall be expressed as the penetration of water.

7.8.3 The average of the four test results for absorption and penetration shall be deemed to be: (a) absorption in percentage, and (b) penetration in millilitre of water by and through the specimen, respectively.

7.9 Repeat the test prescribed in **7.1** to **7.8.3** with the remaining pieces in the test sample.

8 REPORT

The report shall include the following information:

a) The nature of the textile fabric tested;
b) The temperature, hardness and pH value of water used;
c) The period of rain shower exposure to;
d) The number of tests performed;
e) The absorption of water in percent by mass of each test specimen in the sample, the arithmetic mean and range; and
f) The penetration of water (in ml) through each test specimen.

ANNEX A

(*Clause* 6.1)

BUNDESMANN TYPE APPARATUS

A-1 GENERAL DESCRIPTION

A-1.1 The Bundesmann apparatus (*see* Fig.1) shall be provided with a water tank fitted with a number of fine jets to generate a shower of water simulating rainfall. The tank shall be mounted on a fixed height above the four metal test cups provided for mounting the specimens. The cups shall be mounted on the apparatus in such a manner that they can be rotated by means of an electric motor ensuring equal exposure for each specimen to falling water. The interior of each cup (or specimen holder) shall be fitted with an automatically worked wiper device. The wiper arms shall press lightly against the specimen by means of springs so that the specimen is flexed slightly in addition to the rubbing action as the wiper arms pass over its surface. The cups and base plate shall be separated from the electric motor by means of a sheet metal trough.

A-2 SHOWER

A-2.1 The shower tanks shall be provided with 304 brass jets made as shown in Fig. 2. They shall be placed 20 mm apart centre-to-centre.

A-2.2 The means shall be provided for the formation of uniformly spaced drops of average mass 0.075 ± 0.010 g when the rate of flow of water at 27 ± 2°C and *p*H 6 to 8 is established at 65 ± 3ml/min per cup.

A-2.3 The drops shall fall vertically and cover an area greater than that swept by the cups as the cups assembly rotates. The vertical distance between the centre of the specimens when fixed in a position at which the drops are released, shall be 1 500 ± 10 mm.

A-3 CUP ASSEMBLY

A-3.1 The cup assembly shall rotate at 5 ± 1 rev/min under the shower.

A-3.2 Four cups shall be so mounted on the assembly that the specimens are tilted 10 to 15° to the horizontal so as to shed water outwards. The centre of the mounted specimens shall be 105 ± 10 mm from the vertical axis of rotation of the cup assembly.

A-3.3 The cups having a circular orifice shall be provided with clamps of such a kind that an area of the specimen with 100 mm diameter is exposed. There shall be no leakage round the mounted specimen into the cup and through the specimen at the clamps.

A-3.4 An exit hole or aperture of 7 ± 1mm diameter shall be provided for allowing air displacement but not permiting the ingress of water into the cup.The cups shall have a minimum capacity of 350 ml when water fills the cup up to the exit hole. The cup shall be provided with draincocks; having a bore of 3 mm, *Min* so that the water collected may be completely drained.

NOTE — The air exit holes in the cups may be advantageously provided with external metal tubes that are bent in such a way that the impact of the shower on the cup assembly does not cause the water to splash up into the tubes during the test period. This will prevent water that overflows down the cup during the exposure from becoming lodged in the exit hole.

A-3.5 Each cup shall be provided with four wiper arms fixed at right angles to each other and rotating about the axis of the cup. When released the highest point of the wiper arm shall stand 3.0 mm proud of the rim of the cup and the wipers shall press initially against the specimen with a load of 400 ± 50 g. The wiper arms shall sweep an arc of 100 ± 5°, making 20 complete oscillations per minute. The length of the base of the wiper arms shall be 96 mm. the maximum width of the wiper and its support shall not exced 9.5 mm. The horizontal locating surfaces of the wiper supports shall lie in the same plane and this plane shall be at right angles to the axis of rotation of the wiper-head spindle.

A-3.6 The wiping surfaces shall be made from stainless steel of good quality. The operative surface of the wipers shall be formed by machining the material to form a part of the cylinder having a diameter 12.7 ± 0.1 mm with its axis disposed radially about the wiper head spindle when viewed from above and tilted downwards 2° ± 3' when viewed horizontally. The thickness of the wiping surface shall be from 5.08 to 5.13 mm. The extremities of the wipers shall have a radius of 3 mm. The centre of the wipers shall be indented in the form of a cone with a diameter of 13 mm diminishing to 11 mm over a depth of 0.8 mm so that the center of indentation is coaxial with the wiper head spindle and at the intersection of the axis of the wiper cylinders. Care shall be taken to ensure that the ends of the single wiper make a closely fitting but joint with the opposite sides of the doubled wiper. The machining marks shall then be carefully removed by filling parallel to the cylinder axis and final polish given to the surface by Grade 00 emery paper to which is added a little paraffin. Paraffin residues which would contaminate the next specimen to be tested, should be removed by subsequent cleaning, such as, with trichloroethylene.

A-4 FILTER

A-4.1 It is desirable for almost all water supplies, to provide a filter to obviate the need for frequent cleaning of jets. A piece of closely woven cotton fabric, wrapped around a perforated metal support, may be efficient filter for use on Bundesmann type apparatus.

A-5 MECHANICAL SHAKER

A-5.1 A clip for holding the specimen shall be attached at the end of 213 mm long arm to which a torque of 9.7 kgf cm should be applied when this arm is released. The arm shall move through an arc of 170° to the horizontal position and come to rest with a residual torque of 1.15 kgf cm.

A-5.2 The mass of the arm shall be such that the velocity measured tangentially at a radius of 195 mm and at a deflection of 140 ± 5° from the initial position shall be 5.4 ± 0.54 m/s.

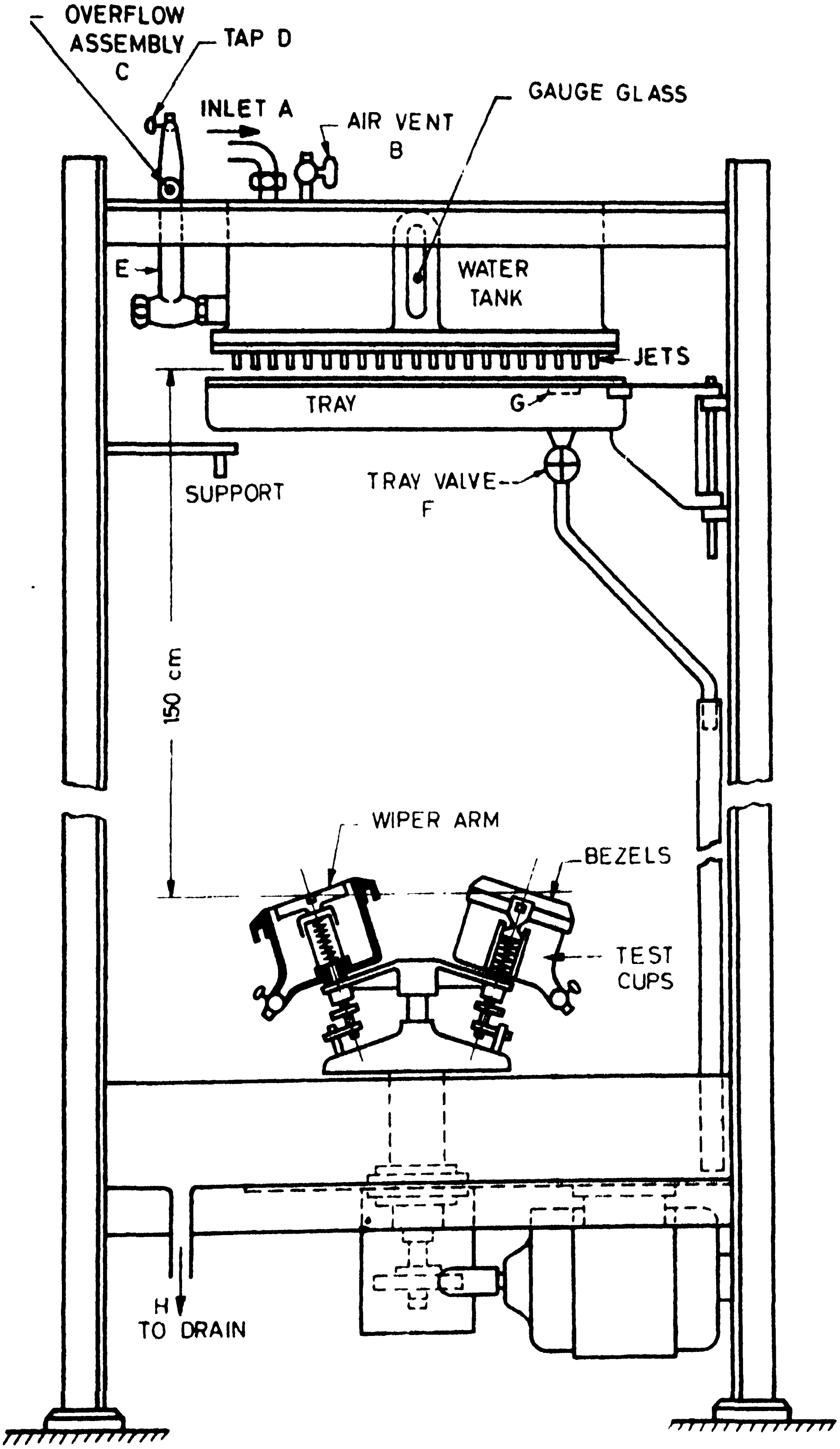
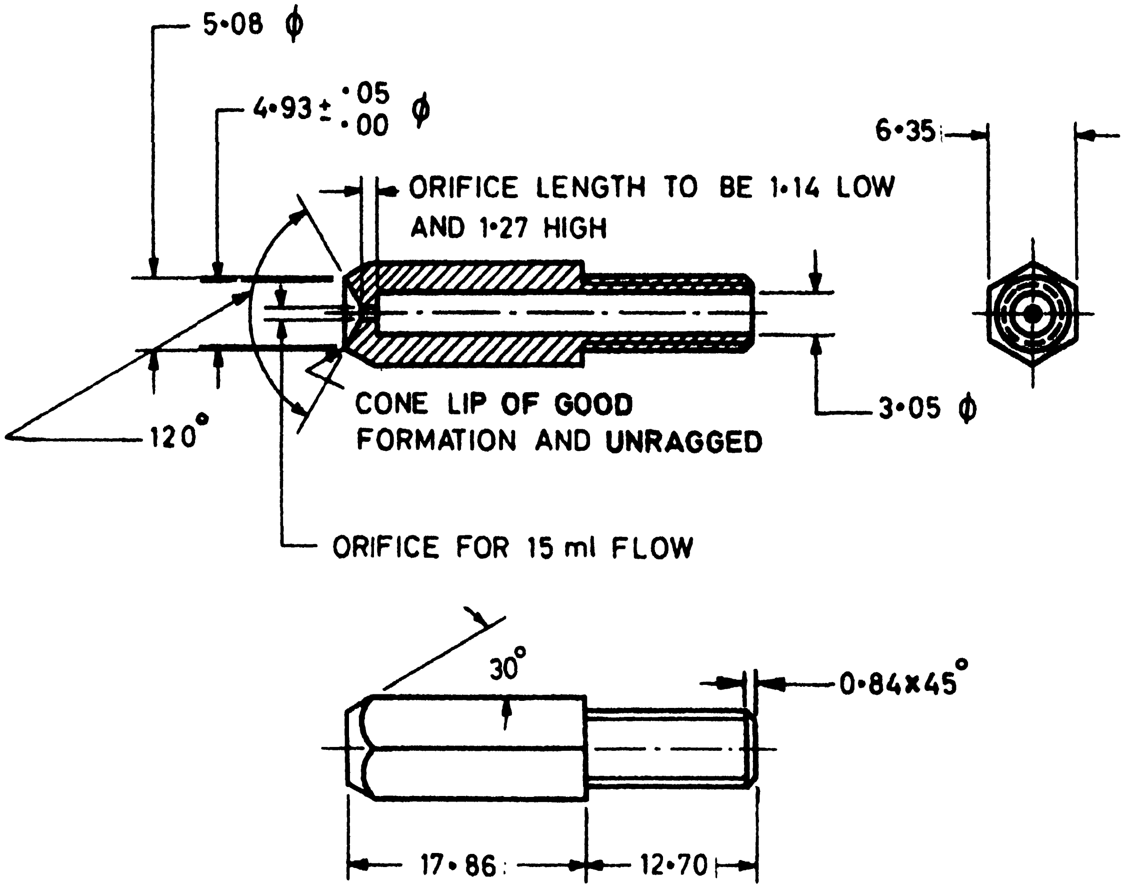


FIG. 1 THE BUNDESMANN TESTER


5•08 ϕ
4•93 ± •05/•00 ϕ
6•35
ORIFICE LENGTH TO BE 1•14 LOW AND 1•27 HIGH
CONE LIP OF GOOD FORMATION AND UNRAGGED
3•05 ϕ
120°
ORIFICE FOR 15 ml FLOW
30°
0•84×45°
17•86
12•70

All dimensions in millimetres.

FIG. 2 JET FOR THE BUNDESMANN TESTER — WATER REPELLENCY TESTING APPARATUS

DETERMINATION OF RESISTANCE TO PENETRATION BY WATER OF FABRICS BY HYDROSTATIC HEAD TEST

(*Source* : **IS 391:1975**)

The hydrostatic head test prescribed in this method is a relatively simple test indicating the effect of fabric structure on its resistance to penetration by water. The resistance offered by the fabrics to penetration of water is expressed in centimetres of static head of water.

1 SCOPE

It prescribes a method of determining the resistance of fabrics (permeable as well as non-permeable to air) to water penetration by hydrostratic head test.

2 SAMPLING

2.1 Samples drawn in compliance with the procedure laid down in the material specification or as agreed to between the buyer and the seller shall be taken as representative of the lot. In case of cotton fabrics reference to IS 3919:1966 'Methods for sampling cotton fabrics for determination of physical characteristics' given in Section A-1/3 shall be made.

2.2 At least eight test specimens, each 100 mm × 100 mm, shall be drawn at random from each individual piece in the test sample.

3 CONDITIONING AND TESTING ATMOSPHERE

3.1 The test specimens shall be conditioned in accordance with IS 6359:1971 'Atmospheric conditions for testing' given in Section B-1/1 except in case of fabrics heavier than 270 g/m^2 for which the minimum conditioning period shall be 48 hours.

3.2 The tests shall be preferably carried out in standard atmosphere. In case it is not possible to carry out the test in standard atmosphere, the specimens shall be conditioned as provided for in **3.1** and tested in prevailing atmosphere immediately thereafter.

4 APPARATUS

4.1 The apparatus shall meet the following requirements:

a) Means shall be provided for clamping the specimen of fabric in such a manner that:
   1) the specimen is horizontal,
   2) a circular area of the fabric (50 mm dia) shall be subjected to a steadily increasing water pressure on one face,
   3) no leakage of water at the clamps shall occur during the test period,
   4) the specimen shall not slip in the clamps, and
   5) any tendency for penetration to occur at the clamped edge of the specimen is arrested.

b) The distilled water in contact with the test specimen shall be maintained at 27 ± 2°C.

c) The rate of increase of water head shall be 100 ± 5 mm/min.

d) The manometer connected to the testing head(s) shall allow pressure to be read to an accuracy of 5 mm head of water.

NOTE — A suitable apparatus is described in Annex A.

5 PROCEDURE

5.1 Prepare the apparatus for the test as advised by the manufacturer. Wipe all water from the clamping surface. Take the specimen and clamp it on the testing head in such a manner that there is an air space between the face of the fabric and the surface of water. Immediately subject the specimen to increasing water pressure [*see* **4.1** (c)]. Watch continuously for evidence of penetration by the water through the specimen.

5.2 Carefully observe for drops of water forced through the cloth. Ignore drops coming through the test specimen at the first two places. Record the head of water in centimetres immediately when a drop of water comes through a third place in the specimen.

5.3 Repeat the test with the remaining test specimens.

6 REPORT

The report shall include the following information:

a) Type of fabric;
b) Number of test specimens tested; and
c) Mean resistance of fabrics, in centimetres of water head.

ANNEX A

(*Note in Clause* 4.1)

HYDROSTATIC HEAD TEST APPARATUS

A-1 DESCRIPTION

A-1.1 The apparatus shall consist of the following (*see* Fig. 1 and 2):

a) *Brass Cylinder* (*M*) – Closed at the bottom and open at the top, provided with a tube *R* at the side, the latter serving as inlet and outlet for water. The smooth flanged top of the cylinder in order to prevent damage to the test specimen, shall be provided with a ring of thin rubber of 50 mm internal diameter (for details and dimensions of the cylinder, *see* Fig. 2).

b) *Ring Clamping Device* – A device to clamp a metal ring to top of cylinder *M* by screw *J*. The metal ring of 50 mm internal diameter, in order to prevent damage to the test specimen, is provided with a ring of thin rubber of 50 mm internal diameter.

c) *Graduated Glass Tube* – With the zero mark exactly in level with the top of the cylinder *M*.

d) *Water Reservoir* (*see* Fig. 1) – To constantly supply water to the constant water head vessel *C*.

e) *Constant Water Head* – The diameter of the end of its outlet tube *G* is so adjusted that when it is delivering water into graduated tube *H*, the level of water in it rises at a constant rate of 100 mm/min.

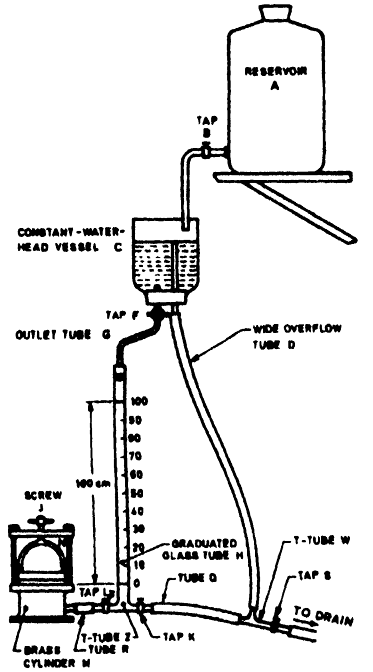
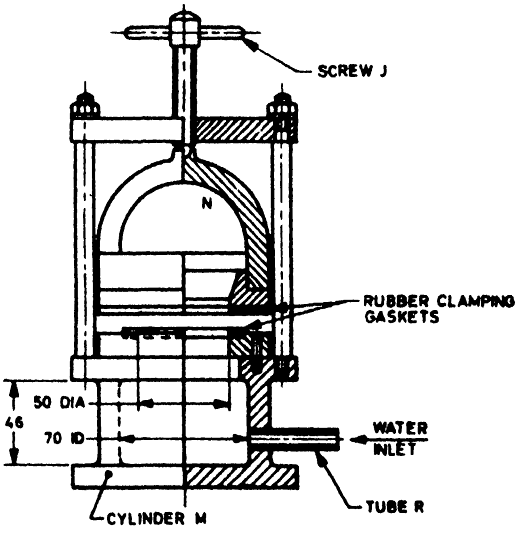


FIG. 1 HYDROSTATIC HEAD TEST APPARATUS



All dimensions in millimetres.

FIG. 2 TEST-HEAD OF HYDROSTATIC HEAD TEST APPARATUS

A-2 OPERATION

A-2.1 Close taps *K*, *L* and F and open taps *S* and *B*. Allow the distilled water from the reservoir *A* (maintained at 27 ± 2°C) to run into the vessel *C* till it attains a constant level (The water will maintain constant level when it has reached the top of the overflow tube *D*, all excess water being drained off through the tube D.). Close tap *S*, open taps *L* and *K* and fill the brass cylinder *M* with water till it is nearly full. Close the tap *K* and open the tap *S*. Lay the test specimen on the rubber ring of the cylinder *M*. Place the clamping ring on top of the test specimen and fix the former rigidly by operating the screw *J*. Open the tap *F* to allow inflow of water into the tube *H* (Just as the level of water in tube *H* begins to go above zero mark the test specimen which is at the same level should begin to bulge.). Continue the flow of water steadily into the graduated tube *H* at such a rate that the level of water in the tube rises by 100 mm/min.

RESISTANCE TO PENETRATION BY WATER OF FABRICS BY STATIC PRESSURE HEAD TEST

(*Source* : IS 7940:1976)

The static pressure head test prescribed in this method is a relatively simple test and gives a good indication of the effect of fabric structure on resistance to penetration by water of fabrics. The resistance by a fabric to penetration of water is measured in terms of the amount of water penetrating through the fabric per unit area per unit time under a static head of water.

1 SCOPE

It prescribes a method for determining resistance to penetration by water of fabrics by static pressure head test. It is applicable to fabrics non-permeable to air.

2 PRINCIPLE

A circular specimen of the fabric is mounted horizontally and water is forced through the specimen from upper side under static pressure. The volume of water collected in a given time is expressed in terms of the volume of water penetrated per unit area of the fabric per unit time ($l/m^2/h$).

3 SAMPLING

Samples shall be so drawn as to be representative of the lot. Samples drawn in compliance with the procedure laid down in the material specification or as agreed to between the buyer and the seller shall be taken as representative of the lot. In case of cotton fabrics reference to IS 5463:1969 'Methods for sampling of cotton fabrics for chemical tests' given in Section A-1/3 shall be made.

4 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

4.1 The test smaples shall be conditioned in accordance with IS 6359:1971 'Method of conditioning of textiles' given in Section B-1/1 except in case of fabrics heavier than 270 g/m^2 for which the minimum conditioning period shall be 48 hours.

4.2 The tests shall be carried out in standard atmosphere

5 PREPARATION OF TEST SPECIMENS

From each test sample prepare circular test specimens of 13 cm diameter from different portions at random. Prepare at least 3 test specimens.

6 EQUIPMENT

6.1 Means for:

a) clamping the specimens with a circular test portion of 10 cm diameter,
b) applying the required static water head pressure and maintaining the pressure throughout the test, and
c) collecting penetrated water without any loss.

6.1.1 A typical equipment is detailed in Annex A.

6.2 Water

Having *p*H between 6 and 8.5 and total hardness not exceeding 50 ppm, maintained at the temperature of testing atmosphere (*see* **4.2**).

7 PROCEDURE

7.1 Adjust the water pressure head level to the required height. Place the container for collecting penetrated water in position. Open the water supply to the apparatus and note the time. Maintain the water level height for 1 hour.

7.2 After 1 hour, immediately remove the water container used for collecting penetrated water and determine the volume of water collected in litres.

7.3 Similarly carry out the test for other test specimens.

8 CALCULATION

8.1 From the volume of water collected as in **7.1** and **7.2** calculate the rate of water penetration (water resistance) in terms of litres per square metre per hour as follows:

$$\text{Rate of water penetration, l/m}^2\text{/h} = \frac{\text{Volume of water collected in litres} \times 100 \times 100}{3.14 \times 5 \times 5}$$

$$= \frac{\text{Volume of water collected in litres} \times 400}{3.14}$$

8.2 Determine the average of all the observations.

9 REPORT

The report shall include the following information:

a) Type of the fabric;
b) Number of specimens tested;
c) Static water pressure head in millimetres; and
d) Rate of water penetration in litres per square metre per hour.

ANNEX A

(*Clause* 6.1.1)

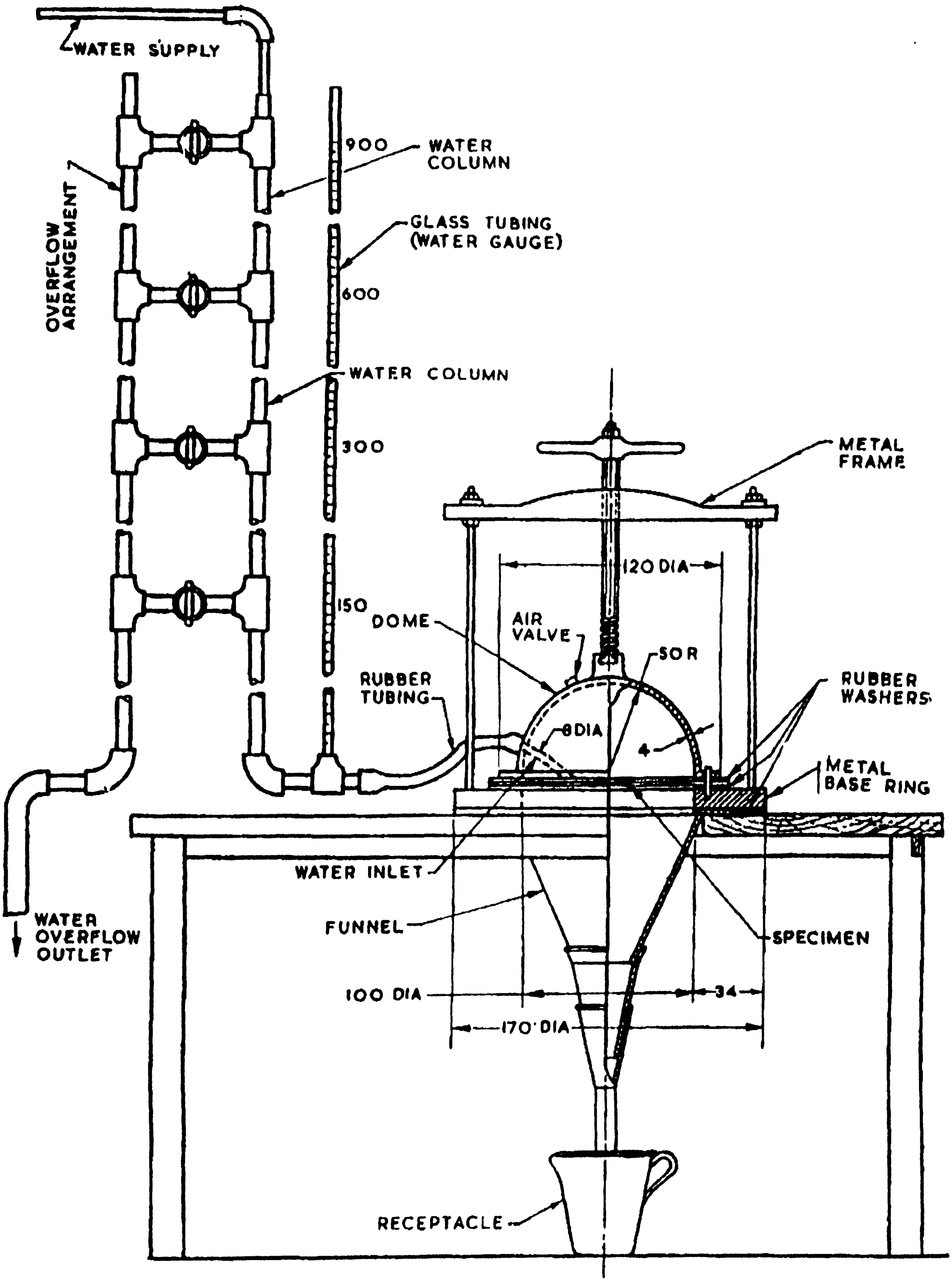
STATIC PRESSURE HEAD TEST APPARATUS

A-1 DESCRIPTION OF THE EQUIPMENT

A-1.1 The apparatus (*see* Fig.1) consists of a metallic base ring with an internal diameter of 10 cm (for holding the specimen), and a metallic dome of diameter 10 cm at the base provided with a water inlet and an air valve. The dome is fitted in a metal frame, so that the dome can be moved up and down or firmly fixed over the base ring. A funnel is fitted under the base ring. To collect water leaking through the specimen, a receptacle is provided. A gauge is attached to the water column for measuring the height of the column. The water column in connected to the water inlet on the metallic dome by means of a rubber tubing. The apparatus is also provided with an overflow arrangememt (to regulate overflow) and an overflow outlet.

A-2 OPERATION

A-2.1 Clamp the specimen under test tightly between the base ring and the dome with the help of rubber washers. Open the water supply and fill the dome with water, taking care that all entrapped air is removed by permitting a little quantity of water to come out of the air valve. When the dome is full of water, close the valve and let the water rise in the water column to the required height (depending upon the type of fabric). Immediately, place the receptacle under funnel. Maintain, for 1 hour, the water column at the required height by adjusting the overflow arrangememt. Immediately after 1 hour, remove the receptacle from under the funnel, and drain off the water in the dome by disconnecting the rubber tubing. Determine the volume of water which has collected in the receptacle in litres.



All dimensions in millimetres

FIG. 1 A TYPICAL STATIC PRESSURE HEAD TEST APPARATUS

DETERMINATION OF RESIDUAL SHRINKAGE OF SPUN POLYESTER SEWING THREADS

(*Source* : **IS 9543:1980**)

1 SCOPE

It prescribes a method for determination of residual shrinkage of spun polyester sewing threads.

2 PRINCIPLE

A sample of textile material under test is exposed to high temperature (in case of dry shrinkage) and alternatively immersed in water and dried (in case of wet shrinkage) and residual shrinkage expressed as percentage decrease in length based on original length of the specimen.

3 APPARATUS

3.1 Mounting Device

The device shall be such that a test specimen of at least 100 cm length can be mounted on it, with one of its ends in a fixed clamp under the desired dead weight tension and

a) exposed to a temperature of 150°C or 180°C as the case may be (in case of dry shrinkage test); and
b) immersed in water at 100°C (in case of wet shrinkage test).

3.1.1 The mounting device shall be provided with means for measuring the initial and final length of test specimens to a range of 1 mm.

a) after exposure to a high temperature (in case of dry shrinkage test); and
b) after immersion in water and drying (in case of wet shrinkage test).

4 PROCEDURE

4.1 Take one of the test specimen and mount it on the mounting device under tension of 0.45 ± 0.09 g per tex. Note the original length of the test specimen.

4.2 In Case of Dry Shrinkage Test

Prepare a small skein of the test specimen and suspend it in an oven at a temperature of 150 ± 2°C or 180 ± 2°C for 15 minutes. Note the final length.

4.3 In Case of Wet Shrinkage Test

Prepare a small skein of the test specimen and immerse it in a test tube containing water. Add a small quantity of soap solution (0.1 percent) to ensure adequate wetting out. In order to prevent local heating, immerse the test tube in a water bath at 100°C and keep it in this position for 15 minutes. Ensure that the water in the water-bath is above the level of water in the test tube throughout the test. Rinse the test specimen in running tap water and allow it to drip dry without tension. Note the final length.

5 CALCULATIONS

Calculate the shrinkage as follows:

$$\text{Shrinkage percent} = \frac{a-b}{a} \times 100$$

where

a = original length of the specimen, and
b = final length of the specimen (*see* **4.2** and **4.3**).

6 REPORT

Report shall include the following

a) Method employed that is wet or dry;
b) Shrinkage obtained (*see* **5**); and
c) Any deviation from the test method.

SECTION D

CHEMICAL TESTS

DETERMINATION OF WOOL CONTENT IN WOOLLEN TEXTILE MATERIALS

(*Source* : **IS 8476:1977**)

The method determines the total protein content in the woollen textiles materials. However, it does not necessarily mean that the protein content so determined is 'all wool'. It may also contain other protein fibres besides 'wool'.

1 SCOPE

It prescribes a method for determination of percentage of wool in all-wool textiles in any form, such as fibre. yarn, fabrics, druggets and carpets.

2 PRINCIPLE

A pretreated specimen of known oven-dry mass is dissolved in sodium or potassium hydroxide. The non-wool content, including burrs, seeds, etc, is over-dried and weighed, and percentage of wool content is calculated therefrom.

3 SAMPLING

Samples shall be so drawn so as to be representative of the lot. A sample drawn in accordance with the procedure laid down in the material specification or as agreed to between the buyer and the seller, shall constitute the test sample.

4 ATMOSPHERIC CONDITIONS FOR CONDITIONING

Condition the test specimen to moisture equilibrium in the standard atmosphere of 27 ± 2°C temperature and 65 ± 2 percent relative humidity [*see* also IS 6359:1971 'Method for conditioning of textiles' (*see* Section B-1/1)].

5 APPARATUS

5.1 Soxhlet Apparatus

5.2 Sintered Glass Crucible No. 1

5.3 Desiccator

5.4 Weighing Balance

Capable of weighing to an accuracy of 10 mg.

5.5 Drying Oven

Capable of maintaining a temperature of 105 ± 3°C and preferably fitted with weighing balance.

6 REAGENTS

6.0 Quality of Reagents

Unless specified otherwise pure chemicals shall be employed in test and distilled water shall be used wherever the use of water as a reagent is intended.

NOTE – 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the test results

6.1 Sodium or Potassium Hydroxide Solution

5 percent (*m/v*).

6.2 Benzene - Methyl Alcohol Mixture (3 : 2).

6.3 Acetic Acid Solution

3 percent (*v/v*).

7 PREPARATION OF TEST SAMPLE

Take the sample weighing about 30 g and cut it into pieces, if necessary. Put it in the Soxhlet apparatus and extract with benzene-methyl alcohol mixture for two hours at a minimum rate of six cycles per hour. Allow the solvent to evaporate and then wash the sample in water (about 500 ml) at 50°C for 30 minutes.

8 PROCEDURE

8.1 Take a representative specimen weighing about 5 g from the prepared sample and place it in a suitable container. Place the specimen in the drying oven maintained at a temperature of 105 ± 3°C and dry it to a constant mass.

NOTE — The mass shall be taken as constant when the difference between the two successive weighings made at intervals of 20 minutes is less than 0.05 percent.

8.2 Determine the mass of the specimen without removing it from the oven. In case the drying oven is not provided with weighing balance, remove the specimen from the oven and transfer it to a weighing container of known mass provided with a tight lid. The transference of the specimen shall be done in as less a time as possible. Cool the specimen and the container in a desiccator to room temperature before weighing. Weigh the container and determine the mass of the specimen to an accuracy of 10 mg.

8.3 Put the specimen in a beaker together with 500 ml of 5 percent sodium or potassium hydroxide solution and boil slowly until the wool fibres dissolve. After 10 minutes of boiling, filter through a sintered glass crucible. Wash the residue first with warm water, then with acetic acid solution and finally with hot water. Dry the residue at 105 ± 3°C.

8.4 Examine carefully the residue and the pores of the crucible for incompletely dissolved wool. If it is present, dissolve it by pouring sodium or potassium hydroxide solution. Rinse and dry the residue at 105 ± 3°C to constant mass (*see* Note under **8.1**) and weigh it to an accuracy of 10 mg.

8.5 Similarly test at least two more test specimens.

9 CALCULATION

9.1 Calculate the wool content for each test specimen as under:

$$\text{Wool content, percent} = \frac{a-b}{a} \times 100$$

where

a = oven dry mass of the specimen; and

b = oven dry mass of the residue.

NOTE — 13.6 is standard moisture regain for wool.

9.2 Calculate the average wool content of all the test specimens.

10 REPORT

The report shall include the following:

a) Type of material;
b) Average wool content, percent; and
c) Number of test specimens.

DETERMINATION OF BITUMEN CONTENT IN LAMINATED JUTE BAGS

(*Source* : IS 8477:1985)

Jute bags laminated with craft paper or polyethylene film using bitumen as the bonding material are extensively used these days for packing materials like pesticides, fertilizers, etc. Two methods, one based on conditioning of the test specimens in a standard atmosphere or in a conditioning chamber and the other based on conditioning of the test specimens in a desiccator containing saturated solution of sodium nitrite were evolved for determining the amount of bitumen used for bonding the liner and the jute fabric as its quantity is important for the performance of the laminated jute bag.

1 SCOPE

It prescribes two methods for determination of bitumen content in laminated jute bags.

2 PRINCIPLE

A specimen of laminated fabric of known mass is taken and the liner is removed by dipping in a suitable solvent and then the fabric portion is extracted in Soxhlet apparatus. From the mass of the initial piece, liner and extracted fabric, the bitumen content is calculated.

3 SAMPLING

3.1 Lot

The quantity of laminated jute bags purported to be of one definite type and quality delivered to a buyer against one despatch note shall constitute a lot.

3.2 The sample shall be so drawn as to be the representative of the lot. The sample drawn in accordance with the procedure laid down in the material specification or as agreed to between the buyer and the seller shall be taken as representative of the lot.

4 PREPARATION OF TEST SPECIMEN

From the sample, cut four pieces of 100 mm × 100 mm taking one piece from the area near the mouth, the other from the area close to the bottom and two pieces from the middle portions of the bag. The pieces shall be taken in such a way that they contain spot application portion in case the bitumen is applied off-set.

5 METHOD 1

5.1 Conditioning of Test Specimens

5.1.1 Before testing, condition the specimens to moisture equilibrium in standard atmosphere at 27 ± 2°C temperature and 65 ± 2 percent relative humidity [*see also* IS 6359:1971 'Method for conditioning of textiles' (*see* Section B-1/1)].

5.1.1.1 When the test specimens have been left in such an atmosphere for at least 24 hours in such a way as to expose, as far as possible, all portions of the specimens to the atmosphere, they shall be deemed to have reached moisture equilibrium.

5.1.2 In case arrangements are not there for conditioning the test specimens in standard atmosphere, these may be conditioned in a conditioning chamber and mass determined immediately after the removal of the test specimens from the conditioning chamber.

5.2 Apparatus and Reagents

5.2.1 *Soxhlet Apparatus*

5.2.2 *Weighing Balance* -- with an accuracy up to 1 mg.

5.2.3 *Solvent* – Light petroleum or any other suitable solvent such as trichloroethylene or perchloroethylene.

5.3 Procedure

5.3.1 Take the conditioned test specimens and determine their collective mass to the nearest milligram.

5.3.2 Wash all the specimens with the solvent (*see* 5.2.3) and carefully separate the liner pieces. Wash the liner pieces with solvent to remove adhering traces of oil and bitumen.

5.3.3 Dry the liner pieces in air and determine their collective mass to the nearest milligram (*see* Note).

NOTE — If the liner pieces are made of craft paper, these shall be conditioned before determining their collective mass.

5.3.4 Take the four fabric pieces obtained after the removal of liner pieces from the test specimens and place them in a thimble of the Soxhlet apparatus. Take about 400 ml of the solvent in the extraction flask. Extract the pieces for 1½ to 2 hours at a rate of about 6 cycles per hour. Take out the fabric pieces and let the solvent evaporate.

5.3.5 Condition the fabric pieces as given in **5.1.1** or **5.1.2** as the case may be, and determine their collective mass to the nearest milligram.

5.3.6 Calculate the quantity of bitumen per square metre as given in **7.1** and **7.1.1**.

6 METHOD 2

6.1 Apparatus and Reagents

6.1.1 *Soxhlet Apparatus*

6.1.2 *Weighing Balance* - With an accuracy up to 1 mg.

6.1.3 *Desiccator* Suitable size, charged with saturated solution of sodium nitrite at 27 ± 2°C.

6.1.4 *Solvent* - Light petroleum or any other suitable solvent such as trichloroethylene or perchloroethylene

6.2 Procedure

6.2.1 Condition all the test specimens (*see* **5.1**) in the desiccator charged with saturated solution of sodium nitrite at 27 ± 2°C for at least 24 hours in such a way that the fabric side of each specimen is exposed to the air inside the desiccator.

6.2.2 Remove all the specimens from the desiccator and immediately determine their collective mass to the nearest milligram.

6.2.3 Wash all the specimens with the solvent (*see* **6.1.4**) and carefully separate the liner pieces. Wash the liner pieces with solvent to remove adhering traces of oil and bitumen.

6.2.4 Dry the liner pieces in air and determine their collective mass to the nearest milligram (*see* Note under **5.3.3**).

6.2.5 Take the four fabric pieces obtained after the removal of the liner pieces from the test specimens and place them in the thimble of the Soxhlet apparatus. Take about 400 ml of the solvent in the extraction flask. Extract the fabric pieces for 1½ to 2 hours at a rate of about 6 cycles per hour. Take out the fabric pieces and let the solvent evaporate.

6.2.6 Place the fabric pieces in the desiccator charged with saturated solution of sodium nitrite at 27 ± 2°C for at least 24 hours exposing both sides of each fabric piece as far as possible to the air inside the desiccator.

6.2.7 Remove the fabric pieces from the desiccator and immediately determine their collective mass to the nearest milligram.

6.2.8 Calculate the quantity of bitumen per square metre as given in **7.1** and **7.1.1**.

7 CALCULATION

7.1 Calculate the quantity of bitumen per square metre by the following formula:

$$X = 25\,[a - (b + c + d)]\ \text{g/m}^2$$

where

X = mass of bitumen per square metre of the laminated fabrics;

a = combined mass of the conditioned test specimens;

b = combined mass of the liner pieces;

c = combined conditioned mass of the extracted fabric pieces; and

d = correction factor for oil content of the fabric.

7.1.1 Calculate the value of d by the following formula:

$$d = \frac{c \times y}{100}$$

where

c = combined conditioned mass of the extracted fabric pieces; and

y = oil content percentage of the fabric as specified in the material specification, on conditioned mass basis (*see* Note).

NOTE — Generally five percent oil content on conditioned mass basis is used for hessian and double-warp thread fabrics made of jute For other fabrics use the value as given in the material specification based on conditioned mass Five percent of oil content on conditioned mass corresponds to six percent of oil content on dry de-oiled material basis.

8 REPORT

The report shall include the following information:

a) Type of material;

b) Bitumen content per square metre; and

c) Method of bitumen application, namely, continuous or off-set bonding.

DETERMINATION OF OIL CONTENT OF JUTE YARN AND FABRICS

(*Source* : IS 2969:1974)

During conversion of jute fibres into yarn considerable amount of oil, commonly known as batching oil, is used in the form of its emulsion in water. Some or all of the oil is present in the later stages of manufacture of jute goods. The finished jute goods usually contain 5 to 9 percent oil. In the case of special goods, the oil content may be up to 1 percent only.

1 SCOPE

It prescribes two methods for determination of oil content of all types of jute yarn and fabrics, namely conditioned-mass method and oven-dry method.

2 PRINCIPLE

A known amount of the sample is extracted with trichloreoethylene or light petroleum or *n*-hexane in Soxhlet apparatus. The solvent is removed by distillation and the extract is weighed. The mass of the extract is expressed as a percentage of the oven-dry mass of the extracted specimen or conditioned mass of the test specimen before extraction.

3 SAMPLING

3.1 Lot

The quantity of jute yarn or fabric purported to be of one definite type and quality delivered to one buyer against one despatch note shall constitute a lot.

3.2 Samples from the lot shall be so drawn as to be representative of the lot. Samples drawn in accordance with the procedure laid down in the specification for the material or as agreed to between the buyer and the seller shall be held to be representative of the lot.

4 PREPARATION OF TEST SPECIMENS

From each bundle of yarn or cut of fabric selected, draw a test specimen weighing 6 to 8 g.

5 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

5.1 Conditioned-Mass Method

The test shall be carried out in the standard atmosphere after conditioning the test specimens as prescribed in IS 6359:1971 'Method for conditioning of textiles' (*see* Section B-1/1).

5.2 Oven-Dry Method

The test may be carried out in the prevailing atmosphere.

6 APPARATUS

6.1 Soxhlet Apparatus

6.2 Drying Oven – capable of maintaining a temperature of 105 ± 3°C.

6.3 Weighing Balance – capable of weighing to an accuracy of 1 mg.

7 REAGENTS

7.1 Quality of Reagents

Unless specified otherwise, pure chemicals shall be employed in test and distilled water shall be used where the use of water as a reagent is intended.

NOTE — 'Pure Chemicals' shall mean chemicals that do not contain impurities which affect the test results.

7.2 The reagents to be used in the test shall be as follows.

7.2.1 *Trichloroethylene*

7.2.2 *Light Petroleum*

7.2.3 *n-hexane*

Boiling range 40 to 60°C.

8 PROCEDURE

8.1 Conditioned-Mass Method

8.1.1 Take a test specimen conditioned in the standard atmosphere (*see* **5.1**), determine its mass (M_C) correct to 1 mg and place it in the thimble of the Soxhlet apparatus. Take about 100 ml of trichloroethylene or light petroleum *n*-hexane in the extraction flask previously cleaned, dried and weighed correct to 1 mg. Extract the test specimen for 1½ to 2 hours with a minimum of 10 siphonings per hour. Disconnect the apparatus.

8.1.2 Recover the excess of the solvent by heating the flask in a water-bath, maintained at 90 to 95°C if the solvent is trichloroethylene, 60 to 65°C if the solvent is light petroleum and 70 to 75°C of the solvent in *n*-hexane, and simultaneously allowing a stream of air to pass through the flask by means of a tube terminating just below its neck. Remove all traces of moisture by heating the flask at 105 ± 3°C for ½ hour. Weigh the flask and determine the mass of the extract (M_c) correct to 1 mg.

8.1.3 Repeat the test with the remaining test specimens.

8.2 Oven-Dry Method

8.2.1 Take a test specimen, weigh it to the nearest milligram and place it in the thimble of the Soxhlet apparatus. Take about 100 ml of trichloroethylene or light petroleum in the extraction flask previously cleaned, dried and weighed correct to 1 mg. Extract the test specimen for 1½ to 2 hours with a minimum of 6 siphonings per hour. Disconnect the apparatus.

8.2.2 Withdraw the specimen from the apparatus, open it out and allow the excess solvent to evaporate. Dry the specimen for 4 hours at 105 ± 3°C in the drying oven. Transfer the dried specimen to a tared airtight container, cool and weigh. Determine the oven-dry mass of the specimen (M_d) correct to 1 mg.

8.2.3 Proceed further as in **8.1.2**.

8.2.4 Repeat the test with the remaining test specimens.

9 CALCULATIONS

9.1 Calculate the oil content percent of each specimen to the nearest 0.1 percent as follows:

Conditioned-mass basis:

$$\text{Oil content percent} = \frac{M_e}{M_c} \times 100$$

where

M_e = mass in milligrams of the extract (**8.1.2**), and
M_c = mass in milligrams of the conditioned specimen (**8.1.1**).

Oven-dry-mass basis:

$$\text{Oil content percent} = \frac{M_e}{M_d} \times 100$$

where

M_e = mass in milligrams of the extract (**8.2.3**), and
M_d = mass in milligrams of the oven-dry de-oiled specimen (**8.2.2**).

9.2 Calculate the average of all the values obtained as in **9.1** to the nearest 0.1 percent.

10 REPORT

The report shall include the following information:

a) Average oil content percent,
b) Method followed, and
c) Number of specimens tested.

DETERMINATION OF HYDROGEN PEROXIDE CONTENT IN TEXTILE MATERIALS

(*Source* : **IS 7045:1973**)

In the textile industry peroxide bleaching is carried out on different machines like kiers, J-boxes, open width bleaching ranges, etc, and is generally used for cotton textiles to impart durable whiteness. The determination of hydrogen peroxide content on fabrics is important for process control. This method can be used for determining the add-on the cloth before and after the treatment. This can also be used for determining the strength to peroxide bath at different stages such as feeding bath and running bath and for determining the rate of consumption of peroxide during the process.

1 SCOPE

It prescribes a method for determination of hydrogen peroxide content in textile materials during process.

2 PRINCIPLE

A small piece of fabric is put in distilled water and then dilute sulphuric acid is added to it and allowed to stand for some time. The solution is then titrated against standard potassium permanganate and the amount of hydrogen peroxide is calculated on the basis of the oven-dry mass of the specimen.

3 SAMPLING

3.1 Test samples to determine the peroxide content of fabrics in a lot shall be selected so as to be representative of the lot.

3.2 Test Specimen

Draw at least two test specimens each weighing about 5 g from different portions of the sample under test.

4 APPARATUS

4.1 Flat-Bottom Flask or Beaker – of 250 ml capacity.

4.2 Measuring Cylinder

4.3 Burette

4.4 Weighing Balance

5 REAGENTS

5.1 Unless specified otherwise pure chemicals shall be employed in tests and distilled water shall be used where the use of water as reagent is intended.

NOTE — 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the test results.

5.2 Potassium Permanganate

0.1 N.

5.3 Sulphuric Acid

20 percent (*v/v*).

6 PROCEDURE

6.1 Cut a test specimen weighing approximately 5 g and directly place it in the flat-bottom flask without weighing. Add 100 ml of distilled water and 10 ml of sulphuric acid. Shake the flask and allow it to stand for 5 minutes. Titrate the contents with potassium permanganate till the first permanent pink colouration appears. Note the volume of potassium permanganate used.

NOTE — In case the volume of potassium permanganate consumed is too small, a lower concentration of potassium permanganate shall be used

6.2 Wash the test specimen with water and dry it to constant mass at 105 ± 3°C and determine its mass.

6.3 Similarly, test the other test specimens.

7 CALCULATIONS

Calculate the percentage of hydrogen peroxide content by the following formula:

$$P = \frac{V}{m} \times 0{\cdot}17$$

where

P = percentage of hydrogen peroxide,

V = volume of potassium permanganate in ml (*see* **6.1**), and

m = mass of the oven-dry test specimen in g (*see* **6.2**).

8 REPORT

Report shall include the following information:

a) Percentage of hydrogen peroxide content, and
b) Number of specimens tested.

DETERMINATION OF SODIUM CHLORITE CONTENT IN TEXTILE MATERIALS

(*Source* : **IS 7044:1973**)

In the textile industry, the chlorite bleach is carried out either on closed jiggers or on closed reaction chambers and is generally used for bleaching polyester-cotton blends. The determination of sodium chlorite content of fabrics is important for process control. This method can be used for determining the add-on on the cloth before and after treatment. This method can also be used for determining the strength of chlorite bath at different stages, feeding bath and running bath, for determining the rate of consumption of chlorite during process.

Determination of sodium chlorite content of finished fabrics is also important especially when these are to be stored for long time before use. For determining sodium chlorite content on finished fabrics the method described in Annex A may be followed.

1 SCOPE

It prescribes a method for determination of sodium chlorite content in textile materials during process.

2 PRINCIPLE

A small piece of fabric is put in distilled water and potassium iodide solution is added and acidified with acetic acid. The liberated iodine is titrated against standard sodium thiosulphate solution and the amount of sodium chlorite content is calculated on the basis of the ovendry mass of the specimen.

3 SAMPLING

3.1 Test sample to determine the chlorite content of fabrics in a lot shall be selected so as to representative of the lot.

3.2 Test Specimens

Draw at least 2 test specimens each weighing about 5 g from different portions of the sample under test.

4 APPARATUS

4.1 Flat-Bottom Flask or Beaker — 250 ml capacity.

4.2 Measuring Cylinder

4.3 Burette

4.4 Weighing Balance

5 REAGENTS

5.1 Unless specified otherwise, pure chemicals shall be employed in tests and distilled water shall be used where the use of water as reagent is intended.

NOTE — 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the test results.

5.2 Potassium Iodide Solution

10 percent.

5.3 Sodium Thiosulphate Solution

0.1 N.

5.4 Acetic Acid

25 percent (*v/v*).

5.5 Starch Indicator

0.5 percent.

6 PROCEDURE

6.1 Cut a test specimen weighing approximately 5 g and directly place it in the flat-bottom flask without weighing. Add 25 ml of distilled water and 15 to 20 ml or potassium iodide solution and acidify with acetic acid. Shake and then let the solution stand for about 5 minutes.

6.2 Titrate the liberated iodine with sodium thiosulphate solution using starch indicator (*see* Note). The end-point shall be taken when the blue colouration disappears. Note the volume of sodium thiosulphate used.

NOTE — Determine the approximate end-point in a preliminary titration so that the starch indicator may be added just prior to reaching the end-point. In case the volume of sodium thiosulphate consumed is too small, a lower concentration of sodium thiosulphate shall be used.

6.3 Wash the test specimen in water and dry it to constant mass at 105 ± 3°C and determine its mass.

6.4 Similarly, test the other test specimens.

7 CALCULATIONS

7.1 Determine the percentage of sodium chlorite content by the following formula:

$$P = \frac{V}{m} \times 0.226$$

where

P = percentage of sodium chlorite,

V = volume of sodium thiosulphate in ml (*see* **6.2**), and

m = mass of the oven-dry test specimen in g (*see* **6.3**).

8 REPORT

Report shall include the following information:

a) Percentage of sodium chlorite content, and

b) Number of specimens tested.

ANNEX A

DETERMINATION OF SODIUM CHLORITE CONTENT OF DRY SPECIMENS

A-1 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

A-1.1 Prior to test, the specimens shall be conditioned for 24 hours to moisture equilibrium in a standard atmosphere of 65 ± 2 percent RH and 27 ± 2°C temperature.

A-2 PROCEDURE

A-2.1 Take the conditioned test specimen and determine its mass (m) accurately. Then follow the procedure as given in **6.1** and **6.2**.

A-2.2 Similarly test at least one more test specimen.

A-2.3 Calculate the percentage of sodium chlorite content as given in **7.1** taking m as the mass of conditioned test specimen (*see* **A-2.1**).

DETERMINATION OF SULPHATE CONTENT IN TEXTILE MATERIALS

(*Source* : IS 4203:1967)

In textile industry, textile materials undergo various treatments in course of which extraneous matter of various types, such as, sizing or finishing material, and water-soluble salts (chlorides and sulphates) is gathered by or added to the textile materials. Such water-soluble substances, if present, in more than certain quantities may have deleterious effect on the fibrous material or on other materials with which they are associated in use and may, therefore, it affect their performance in service.

1 SCOPE

It prescribes two methods for determination of water-soluble sulphates present in textile materials, and the procedure for extracting the textile materials with water.

2 PRINCIPLE

The aqueous extract of textile material is prepared, the sulphate content is determined, either gravimetrically or volumetrically and expressed as the percentage of the weight of the conditioned material.

3 SAMPLING

3.1 Sampling for Fibre and Yarn

3.1.1 *Lot* (*Fibre or Yarn*)

The quantity of fibre or yarn from the same source shall constitute a lot. If the lot contains more than 200 kg of fibre or yarn, it shall be divided in sub-lots each weighing 200 kg or less.

3.1.2 From a sub-lot 15 increments each approximately weighing 10 g shall be taken from different parts so that a representative sample is obtained. All the increments thus collected shall be thoroughly mixed. This shall constitute the test sample.

3.2 Sampling for Fabrics

3.2.1 *Lot* (*Fabric*)

The quantity of fabric manufacturer under relatively uniform conditions shall constitute a lot.

3.2.2 The number of pieces to be selected from a lot shall be as given below. The pieces thus selected shall constitute the gross sample:

Lot Size	*Sample Size*
Up to 100	3
101 " 300	4
301 " 500	5
501 and above	7

3.2.3 From each piece in the gross sample about 25 g of fabric shall be taken out from at least two different parts. The parts shall then be cut into further smaller pieces and thoroughly mixed. The pieces thus collected shall constitute the test sample.

4 TEST SPECIMENS

From the test sample draw at least two test specimens each weighing about 10 g. Cut the test specimens into small pieces. If the sample under analysis is loose fibre, take about 5 g of the test specimen.

5 CONDITIONING OF TEST SPECIMENS

Prior to test, the test specimens shall be conditioned for 24 hours to moisture equilibrium in a standard atmosphere at 65 ± 2 percent relative humidity and 27 ± 2°C.

6 APPARATUS

6.1 Flat-Bottom Flask – of a suitable capacity with a glass stopper.

6.2 Water-Cooled Condensers

6.3 Gooch Crucible – with asbestos pad.

7 QUALITY OF REAGENTS

Unless specified otherwise pure chemicals shall be employed in tests and distilled water shall be used where the use of water as reagent is intended.

NOTE — 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the test results.

8 PREPARATION OF AQUEOUS EXTRACT

8.1 Condition the test specimens to moisture equilibrium in the standard atmosphere and weigh accurately each test specimen.

8.2 Put a test specimen in the flask and add sufficient amount of water into it to make liquor to material ratio of 20:1 (*see* Note). Connect the flask to the condenser and bring rapidly to the boil and continue to boil the liquor gently for 60 minutes. Disconnect and remove the flask while the liquor is still boiling and close it immediately with the glass stopper fitted with the stopcock. Rapidly cool the flask to room temperature (27°C). Do not remove or open the tap until ready for filtration.

NOTE — If the test specimen is wool in any form, felt or loose fibre masses of any composition, the liquor to material ratio should be 50 : 1.

8.3 Similarly prepare separate extracts for each of the remaining test specimens.

9 GRAVIMETRIC METHOD

9.1 Reagents

9.1.1 *Barium Chloride Solution*

2 percent (*w/v*).

9.1.2 *Hydrochloric Acid*

Concentrated.

9.2 Procedure

9.2.1 Take a measured portion of extract. Filter through a suitable filter paper (*see* Note) and wash the filter paper with distilled water. Add concentrated hydrochloric acid drop by drop to the combined filtrate and washings until the solution is just acidic to litmus, then add 1 ml of acid per 100 ml of solution. Boil the solution for 5 minutes and leave it to cool overnight. Filter off any precipitate on a filter paper-pulp pad. Wash with water and heat the combined filtrate and washings to boiling. To the boiling solution add drop by drop 10 ml of hot barium chloride solution. Boil for 30 minutes and leave to cool overnight. Transfer the precipitate quantitatively to an ignited tared Gooch crucible with asbestos pad and wash with cold water until the washings are free from chloride. Ignite the crucible and its contents gently at first and finally at 800° to 900° C to constant weight.

NOTE — Whatman No. 41 paper is suitable

9.2.2 Carry out the blank determination.

9.2.3 Calculate the percentage of water-soluble sulphate by either of the following formulae:

a) For all materials in yarn and fabric form other than wool (*See* Note 1):

$$P = \frac{823 \times (a-b)}{v}$$

b) For wool in any textile form and for felts and loose fibre masses of any composition (*see* Note 2) :

$$P = \frac{2 \cdot 058 \times (a-b)}{v}$$

where

P = percentage, by weight, of water-soluble sulphates as sulphateion;

a = weight, in g, of the precipitate obtained in the test (*see* **9.2.1**);

b = weight in g, of the precipitate obtained as in blank (*see* **9.2.2**); and

v = volume, in ml, of extract taken for the test.

NOTES

1 100 ml of extract is equivalent to 5.0 g of conditioned test specimen.

2 100 ml of extract is equivalent to 2.0 g of conditioned test specimen.

9.2.4 Repeat the test with the extracts of the remaining test specimens and calculate the percentage of water-soluble sulphate in each test specimen.

9.2.5 Calculate the average of the values obtained as in **9.2.3** and **9.2.4**.

10 VOLUMETRIC METHOD

10.1 Reagents

10.1.1 *Benzidine Hydrochloride Solution*

Prepared as follows:

Dissolve 5 g of benzidine hydrochloride in 40 ml of 1 N hydrochloric acid and dilute the solution to 250 ml with

50 percent aqueous ethanol (*v/v*). Heat the solution to boil, cool, filter if necessary, and store in a dark glass stoppered bottle.

10.1.2 *Alcohol*

95 percent (*v/v*).

10.1.3 *Standard Sodium Hydroxide Solution*

0.02N.

10.1.4 *Standard Sulphuric Acid*

0.02 N.

10.1.5 *Phenol Red Indicator*

0.25 percent (*w/v*) prepared in 25 percent ethanol (*v/v*).

10.2 Procedure

10.2.1 Take a measured portion of extract (*see* **8.2**) and concentrate it to 20 ml. Add to this 20 ml of alcohol followed by 20 ml of benzidine hydrochloride solution. Allow the solution to stand for 30 minutes. Filter the solution under low suction through a suitable filter paper (*see* Note 1). Wash the precipitate with 5 ml of alcohol and repeat the washing 4 times more. After the test washing transfer the precipitate and filter paper to 250 ml conical flask and add 25 ml of distilled water. Add few drops of phenol red indicator. Heat the solution to boiling and cool. Add a known volume of standard sodium hydroxide solution to the contents of the flask, shake thoroughly to dissolve all the precipitate, add more phenol red indicator as required and back titrate the excess of sodium hydroxide with standard sulphuric acid.

NOTES

1 Whatman No. 42 paper is suitable.

2 The accuracy of the above method may be checked by determining the sulphur content in 2 ml of sodium sulphate solution of known strength. 2 ml of sodium sulphate solution is taken in beaker and 8 ml of alcohol is added. To this 4 ml of benzidine hydrochloride is added. The solution is allowed to stand for 30 minutes. The precipitate is filtered and titrated against 0.02 N sodium hydroxide as above.

10.2.2 Calculate the percentage of water-soluble sulphates by either of the following formulae:

a) For all materials in yarn and fabric form, other than wool (*see* Note 1):

$$P = \frac{A \times B \times 4{\cdot}8}{V} \times 20$$

b) For wool in any textile form and for felts and loose fibre masses of any composition (*see* Note 2):

$$P = \frac{A \times B \times 4{\cdot}8}{V} \times 50$$

where

P = percentage, by weight, of water-soluble sulphate as sulphate on;

A = volume, in ml, of standard sodium hydroxide solution;

B = normality of sodium hydroxide solution; and

V = volume, in ml, of the extract.

NOTES

1 100 ml of extract is equivalent to 5.0 g of conditioned test specimen.

2 100 ml of the extract is equivalent to 2.0 g of conditioned test specimen

10.2.3 Repeat the test with the remaining test specimens and calculate the percentage of water soluble sulphate in each test specimen.

10.2.4 Calculate the average of the values obtained as in **10.2.2** and **10.2.3**.

11 REPORT

11.1 Report the values obtained as in **9.2.5** or **10.2.4** as the percentage of sulphate content as sulphate ions in textile materials.

NOTE — If the percentage of water-soluble sulphate is to be expressed as sodium sulphate, multiply P by 1.48.

11.2 Report also the method used (whether gravimetric or volumetric).

DETERMINATION OF CHLORIDE CONTENT OF TEXTILE MATERIALS

(*Source* : **IS 4202 : 1967**)

In textile industry, textile materials undergo various treatments in course of which extraneous matter of various types, such as sizing or finishing material, water-soluble salts (chlorides and sulphates) is gathered by or added to the textile materials. Such water-soluble substances, if present, in more than certain quantities may have deleterious effects on the fibrous material or on other materials with which they are associated in use and may, therefore, affect their performance in service . It is hoped that this method will be useful for determining the chloride content in aqueous extract of textile materials.

The gravimetric and volumetric methods for estimating the chloride content in textile materials are prescribed in this test method. The potentiometric titration method which is suitable for very small quantities of chloride present in textile materials is also given as third method.

1 SCOPE

It prescribes three methods for determination of water soluble chloride in textile materials and the procedure for extracting the textile materials with water.

2 PRINCIPLE

The aqueous extract of textile material is prepared, the chloride content is determined, either gravimetrically or volumetrically and expressed as the percentage of the weight of the conditioned material.

3 SAMPLING

3.1 Sampling for Fibre and Yarn

3.1.1 *Lot* (*Fibre or Yarn*)

The quantity of fibre or yarn from the same source shall constitue a lot. If the lot contains more than 200 kg of fibre or yarn, it shall be divided in sub-lots each weighing 200 kg or less.

3.1.2 From a sub-lot 15 increments each approximately weighing 10 g shall be taken from different parts so that a representative sample is obtained. All the increments thus collected shall be thoroughly mixed. This shall constitute the test sample.

3.2 Sampling for Fabrics

3.2.1 *Lot* (*Fabric*)

The quantity of fabrics manufactured under relatively uniform conditions shall constitute a lot.

3.2.2 The number of pieces to be selected from a lot shall be as given below. The pieces thus selected shall constitute the gross sample:

Lot Size	*Sample Size*
Up to 100	3
101 " 300	4
301 " 500	5
501 and above	7

3.2.3 From each piece in the gross sample about 25 g of fabric shall be taken out from at least two different parts. The parts shall then be cut into further smaller pieces and thoroughly mixed. The pieces thus collected shall constitute the test sample.

4 TEST SPECIMENS

From the test sample, draw at least two test specimens each weighing about 10 g. Cut the test specimens into small pieces. If the sample under analysis is loose fibre, take about 5 g of the test specimen.

5 CONDITIONING OF TEST SPECIMENS

Prior to test, the test specimens shall be conditioned for 24 hours to moisture equilibrium in a standard atmosphere at 65 ± 2 percent relative humidity and 27 ± 2°C temperature (*see* IS 6359:1971 'Methods of conditioning of textiles' given in Section B-1/1).

6 APPARATUS

6.1 Flat-Bottom Flask – of a suitable capacity with a glass stopper.

6.2 Water-Cooled Condensers

6.3 Sintered-Glass Crucible

Porosity 4.

6.4 Titration Vessel and Reference Half-Cell

With suitable *p*H meter as used with glass electrode balanced to read in millivolts, or galvanometer and tapping key. A convenient arrangement is shown in Fig. 1. The half-cell is filled with a suspension made by dissolving 14 g of sodium oxalate and 10 g of potassium nitrate in one litre of distilled water, adding with constant stirring, 100 ml of 0.1 N silver nitrate solution.

NOTE – The stock of suspension should be kept in dark glass bottle.

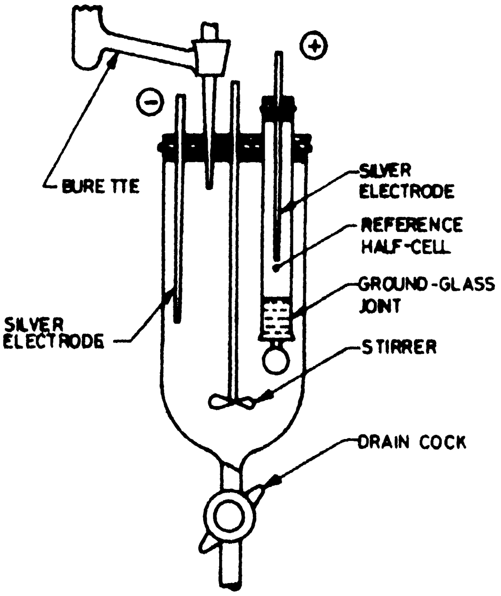


FIG. 1 TITRATION VESSEL AND REFERENCE HALF-CELL

7 QUALITY OF REAGENTS

Unless specified otherwise pure chemicals shall be employed in tests and distilled water shall be used where the use of water as reagent is intended.

NOTE — 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the test results.

8 PREPARATION OF AQUEOUS EXTRACT

8.1 Condition the test specimens to moisture equilibrium in the standard atmosphere and weigh accurately each test specimen.

8.2 Put a test specimen in the flask and add sufficient amount of water to it to make liquor in material ratio of 20:1 (*see* Note). Connect the flask to the condenser and bring rapidly to the boil and continue to boil the liquor gently for 60 minutes. Disconnect and remove the flask while the liquor is still boiling and close it immediately with the glass stopper fitted with the stopcock. Rapidly cool the flask to room temperature (27°C). Do not remove or open the tap until ready for filtration.

NOTE — If the test specimen is wool in any form, felt or loose fibre masses of any composition, the liquor to material ratio should be 50:1.

8.3 Similarly prepare separate extracts for each of the remaining test specimens.

9 FIRST METHOD (GRAVIMETRIC)

9.1 Reagents

9.1.1 *Silver Nitrate Solution*

0.1 N.

9.1.2 *Nitric Acid*

a) concentrated (sp gr 1.42)
b) 0.5 percent (*w/v*)

9.2 Procedure

9.2.1 Take a suitable measured portion of extract (*see* 8.2). Add 5 ml of concentrated nitric acid per 100 ml, boil for 5 minutes and leave it over-night. Filter through a paper-pulp pad, wash with distilled water and add a slight excess of 0.1N silver nitrate solution to the combined filtrate and washings. Heat the solution, protected from direct light, in a water bath until the precipitate is coagulated and supernatant liquor is clear. Verify completeness of precipitation by adding a drop of 0.1 N silver nitrate solution to the supernantant liquor. Allow it to cool overnight in the dark and then filter through a tared sintered-glass crucible. Wash the precipitate with 0.5 percent nitric acid until the washings give no opalescence when tested with sodium chloride solution. Dry the crucible first at 100°C and finally to constant weight at 130 to 150°C.

9.2.2 Carry out a blank determination.

9.2.3 Calculate the chloride content of the test specimen by either of the following formulae:

a) For materials in yarn and fabric form other than wool (*see* Note 1):

$$P = \frac{495 \times (A - B)}{V}$$

b) For wool in any textile form and for felts and loose fibre masses of any composition (*see* Note 2) :

$$P = \frac{1\,237 \times (A - B)}{V}$$

where

P = percentage, by weight, of water-soluble chloride as chloride ion;

A = weight, in g, of the precipitate obtained in the test (*see* **9.2.1**);

B = weight, in g, of the precipitate obtained in blank (*see* **9.2.2**); and

V = volume, in ml, of the extract taken for the test (*see* **9.2.1**).

NOTES

1 100 ml of extract is equivalent to 5.0 g of conditioned test specimen.

2 100 ml of extract is equivalent to 2.0 g of conditioned test specimen.

9.2.4 Repeat the test with the extracts of the remaining test specimens.

9.2.5 Calculate the average of the values obtained as in **9.2.3** and **9.2.4**.

10 SECOND METHOD (VOLUMETRIC)

10.1 Reagents

10.1.1 *Standard Silver Nitrate Solution*

0·1 N.

10.1.2 *Standard Potassium Thiocyanate Solution*

0·1 N.

10.1.3 *Ferric Alum Indicator Solution*

Dissolve 100 g of ferric ammonium sulphate in 250 ml of water. Heat the solution to boiling and add concentrated nitric acid (sp gr 1.42) slowly until the red colour disappears.

NOTE — The amount of nitric acid used should be between 6 and 15 ml.

10.2 Procedure

10.2.1 Take a suitable measured portion of extract. Acidify it with 5 ml of nitric acid. Add 5 ml of 0.1 N silver nitrate solution and 5 ml ferric alum indicator solution. Add sufficient amount of nitrobenzene (*see* Note). Titrate the excess of the silver nitrate against 0.1 N potassium thiocyanate solution till the first appearance of faint pink colour.

NOTE — About 1 ml of nitrobenzene is required in every 0.05 g of chloride

10.2.2 Calculate the chloride content of the test specimen by either of the following formulae:

a) For materials in yarn and fabric form other than wool (*see* Note 1):

$$P = \frac{(AB - CD) \times 3.55}{V} \times 20$$

b) For wool in any textile form and for felts and loose fibre masses of any composition (*see* Note 2):

$$P = \frac{(AB - CD) \times 3.55}{V} \times 50$$

where

P = percentage, by weight, of water-soluble chloride as chloride ion;

A = volume, in ml, of silver nitrate solution;

B = normality of silver nitrate solution;

C = volume, in ml, of potassium thiocyanate, required for back titration;

D = normality of potassium thiocyanate solution; and

V = volume in ml, of extract taken for test.

NOTES

1 100 ml of extract is equivalent to 5.0 g of conditioned test specimen.

2 100 ml of extract is equivalent to 2.0 g of conditioned test specimen.

10.2.3 Repeat the test with the extracts of the remaining test specimens.

10.2.4 Calculate the average of the results obtained as in **10.2.2** and **10.2.3**.

11 THIRD METHOD (POTENTIOMETRIC TITRATION)

11.1 Reagents

11.1.1 *Silver Nitrate Solution*

0.01 N

11.1.2 *Nitric Acid*

Concentrated (sp gr 1.42).

11.2 Procedure

11.2.1 Take a suitable measured portion of the extract (*see* **8.2**). Add 5 ml of concentrated nitric acid per 100 ml of extract and boil for five minutes. Cool rapidly to room temperature and transfer to the titration vessel. Start the stirrer, connect the electrodes to the *p*H meter balanced to read in millivolts and titrate with 0.01 N silver nitrate solution until the galvanometer first indicates zero.

11.2.2 Carry out a blank determination.

NOTE — Before each test, it should be verified that all parts of the apparatus are clean. The silver electrodes should be cleaned with very fine abrasive or a suitable chemical method. Discard and replace the silver oxalate suspension at the first sign of darkening, and to delay darkening half-cell should be shielded from light when not in use. The suspension bottle should be shaken thoroughly before replenshing the half-cell. Take particular care that electrolytes do not come into contact with the junction between the silver wire electrodes and their leads to the *p*H meter. Flush the electrolyte junction after each determination by easing the stopper at the bottom of the half cell to allow fresh extract suspension to flow into the junction.

11.2.3 Calculate the chloride content of the test specimen by either of the following formulae:

a) For materials in yarn and fabric form, other than wool (*see* Note 1):

$$P = \frac{0\cdot 71 \times (V_1 - V_2)}{V}$$

b) For wool in any textile form and for felts and loose fibre masses of any composition (*see* Note 2)

$$P = \frac{1\cdot 77 \times (V_1 - V_2)}{V}$$

where

P = percentage, by weight, of chloride content as chloride ion;

V_1 = volume, in ml, of 0.01 N silver nitrate solution required for test (*see* **11.2.1**);

V_2 = volume, in ml, of 0.01 N silver nitrate solution required for blank (*see* **11.2.2**); and

V = volume, in ml, of extract taken for the test.

NOTES

1 100 ml of the extract is equivalent to 5.0 g of conditioned test specimen.

2 100 ml of the extract is equivalent to 2.0 g of conditioned test specimen.

11.2.4 Repeat the test with the extracts of the remaining test specimens and calculate the percentage of water-soluble chloride in each test specimen.

11.2.5 Calculate the average of the values obtained as in **11.2.3** and **11.2.4**.

12 REPORT

12.1 Report the value obtained as in **9.2.5**, **10.2.4** or **11.2.5** as the percentage of water-soluble chloride as chloride ions in textile materials.

NOTE — If the percentage of the water-soluble chlorides is to be expressed as sodium chloride, then multiply *p* by 1.65.

12.2 Report also the method used (whether gravimetric, volumetric or potentiometric titration.)

ESTIMATION OF RESIDUAL CHLORINE IN COTTON TEXTILE MATERIALS

(*Source* : IS 2350 : 1963)

In the cotton textile industry, cotton in the form of fibres, yarn and fabric is treated with different oxidizing agents during the various chemical processing treatments. Garments inclusive of those made from fabrics which have been given a crease-resistant finish are also treated with the oxidizing agents during the laundering process. Normally, solutions of sodium or calcium hypochlorite are used as oxidizing agents. The unreacted hypochlorite present in the material after the oxidizing treatment is completed, is removed from it by washing and/or antichlor treatments. However, some chlorine is retained by the material either due to improper washing and antichlor treatments or due to the absence of the antichlor treatments. This residual chlorine present on the material makes it yellow on storage and also degrades it if the latter comes in contact with a hot surface, for example, during drying or ironing.

The method of test prescribed here consists of suspending the cotton textile material treated with a hypochlorite in solution of potassium iodide containing hydrochloric acid and titrating the liberated iodine against sodium thiosulphate solution. The amount of the iodine liberated is equivalent to the available chlorine present in the cotton textile material.

1 SCOPE

It prescribes a method for estimating the residual chlorine present in cotton textile materials treated with hypochlorite solution.

2 TERMINOLOGY

For the purpose of this standard, the following definitions shall apply.

2.1 Available Chlorine

The amount of chlorine liberated by the reaction of the material with acid.

2.2 Residual Chlorine

The quantity of available chlorine present in the material at any specified period.

3 SAMPLING

3.1 Sample to estimate the residual chlorine present in cotton textile material in a lot shall be selected so as to be representative of the lot.

3.2 Sample drawn in compliance with an agreement between the buyer and the seller to estimate the residual chlorine content of the material in the lot shall be held to be representative of the lot.

3.3 In the absence of an agreed method of drawing representative sample, the sample selected to represent the lot shall consist of 100 g of the material drawn at random from the material constituting the lot.

4 TEST SPECIMENS

Cut the sample under test (*see* **3.2** and **3.3**) into small pieces. Mix all the pieces thoroughly. Draw at least four specimens from these pieces, such that each specimen weighs 2 to 5g. These specimens shall constitute the test specimens.

5 APPARATUS

5.1 Burette – of 50 ml capacity.

5.2 Erlenmeyer Flask – of pyrex glass or similar resistant glass fitted with a glass stopper, and of 500 ml capacity.

6 REAGENTS

6.1 Quality of Reagents

Unless specified otherwise, pure chemicals shall be employed in the tests and distilled water shall be used where the use of water as a reagent is intended.

NOTE — 'Pure chemicals' shall mean chemicals that do not contain impurities which affect ther results of analysis

6.2 Standard Sodium Thiosulphate Solution

0.01 N, prepared from sodium thiosulphate conforming to IS 246:1986 'Sodium thiosulphate, crystalline, photographic grade'.

6.3 Starch Solution

0.2 percent (*w/v*).

6.4 Hydrochloric Acid

0.1 N, prepared from hydrochloric acid conforming to IS 265:1993 'Hydrochloric acid'.

6.5 Potassium Iodide

7 PROCEDURE

7.1 Determine the moisture content, percent, of the material as follows.

7.1.1 Take a test specimen (*see* **4**). Determine its moisture content, percent, by the method prescribed in **5** of IS 199:1989 'Method for estimation of moisture, total size or finish, ash, and fatty matter in grey and finished cotton textile materials' as given in section D/25.

7.1.2 Determine similarly the moisture content, percent, on a second test specimen.

7.1.3 Calculate the mean of the two values obtained as in **7.1.1** and **7.1.2** and take that to be the moisture content, percent, of the material in the lot.

7.2 Take one test specimen and weigh it accurately. Transfer the test specimen to the flask (*see* **5.2**). Add 190 ml of water, 10 ml of 0.1 N hydrochloric acid and 2 g of potassium iodide to the flask. Stopper the flask and shake it gently to mix the contents thoroughly and allow the contents to stand for one hour at room temperature. At the end of the period, titrate the liberated iodine against 0.01 N thiosulphate solution (*see* **6.2**). When the colour of the solution in the flask is pale-yellow, add 2 ml of the starch solution to it and continue the titration dropwise until the blue colour of the solution just disapears. This shall be taken as the end point.

7.3 Carry out a blank titration following the same procedure (*see* **7.2**) but without the test specimen.

7.4 Calculate the residual chlorine in the test specimen as the percent available chlorine, by the following formula:

Residual chlorine expressed as percent available chlorine of the test specimen $= \dfrac{(V_1 - V_2)\times N \times 0{\cdot}0354\,6 \times 10\,000}{W(100 - M)}$

where

V_1 = quantity, in millilitres, of thiosulphate solution required for the specimen;

V_2 = quantity, in millilitres, of thiosulphate solution required for the blank;

N = normality of thiosulphate solution;

W = Weight in g of the test specimen; and

M = moisture content, percent, of the material in the lot.

7.5 Repeat the test (*see* **7.2** and **7.3**) with the remaining test specimen(s) and calculate the residual chlorine in the test specimen(s) as the percent available chlorine of the test specimen(s).

8 REPORT

Report the mean of all the values obtained (*see* **7.4** and **7.5**) as the residual chlorine present in the cotton textile material expressed as percent available chlorine of the material in the lot.

DETERMINATION OF SMALL QUANTITIES OF COPPER, IRON, MANGANESE, CHROMIUM AND ZINC IN TEXTILE MATERIALS

(*Source* : **IS 1039 : 1989**)

The presence of metals (such as copper, iron, manganese, chromium and zinc) even in small quantities, rubberized, oil-coated or similarly proofed cotton fabrics (or in basic fabric intended to be proofed) tender the fabric on reaction with cellulose or otherwise deteriorate it. The methods prescribed are applicable in estimating metals when present individually or in combination with others. Every precautions should be taken to protect the fabric being sampled, the samples and the apparatus and reagents used, from adventitious contamination both before and during the test and chemicals of the analytical reagents grade and absolutely clean apparatus should be used.

The accuracy of the methods prescribed depends to a large extent on the ability of analyst and use of pure chemicals.

1 SCOPE

1.1 It prescribes methods for the estimation of small quantities of copper, iron, manganese, chromium and zinc in all kinds of textiles.

1.2 The methods of test prescribed in this standard are applicable only if the total quantity of all the metals present does not exceed 0.2 percent (*m/v*) in any one of the test solutions or suspensions.

2 SAMPLING

The sample from the lot shall be drawn so as to be representative of the lot. Sample drawn in accordance with the procedure specified in relevant material specification or as agreed to between the buyer and the seller shall be taken as representative of the lot.

3 PREPARATION OF TEST SPECIMEN

The test sample shall be constituted of pieces or swatches of approximately one square metre. From each such swatch, four test specimens, 7.5 cm × 7.5 cm each, shall be cut out from random locations. All the test specimens shall then be shredded into fine fragments and mixed thoroughly.

4 APPARATUS

4.1 Flat Bottomed Conical Flasks with Neck Extensions, of 150 ml or 250 ml capacity.

4.2 Sintered Porecelain Crucibles, of appropriate capacity.

4.3 A Muffle Furnace

4.4 Spectrophotometer or Spekker Absorptiometer or Colorimeter

4.5 Hot Plate, with provision for maintaining graded surface temperatures.

4.6 Safety Glass Screen

4.7 Boiling Rods, made by rotating suitable lengths of 5 mm diameter glass tubing in a small flame impinging about 10 mm from one end, until the wall at that point is completely fused leaving a small cup beyond. This cup is immersed in the liquid when the rod is in use.

5 QUALITY OF REAGENTS

Unless specified otherwise, pure chemicals shall be employed in tests and distilled water shall be used where the use of water as a reagent is intended.

NOTE – 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the test results.

6 ESTIMATION OF COPPER (Cu)

6.1 Destruction of the Organic Matter

6.1.1 *Method 1 - Wet Ashing*

This method is preferable to Method 2, particularly when the amount of copper is very small, or when substances containing silicon (for example, china clay) are present. Prepare wet ash of the test specimen by the method prescribed in Annex A. Also prepare a 'blank' by evaporating appropriate quantities of the acids to about the same volume as that of the residue from the combustion. Take particular care to expel chlorine completely from both solutions.

6.1.2 *Method 2 - Dry Ashing*

Determine the mass of the test specimen before ashing, place in a porcelain crucible and impregnate with 5 percent solution of magnesium nitrate at the rate of 1 ml per gram of the test specimen. Alcohol may be used to facilitate the impregnation of grey cotton or poorly wettable materials. Take care to ensure that the inner surfaces of the curcible have not been damaged or roughened as this may lead to loss of copper by combination with the glaze. Prepare dry ash of the test specimen as prescribed in IS 199:1989 (*see* Section D/25) and dissolve the ash by heating on a water-bath with 5 ml of 2N sulphuric acid and prepare a 'blank' by mixing 5 ml of the same acid with the appropriate quantity of magnesium nitrate.

6.2 Selection of Method

6.2.1 The dithizone method (Method B) is more sensitive, but the choice depends largely upon the amount and nature of other substances present; the effects of different extraneous ions are summarized in Table 1. The amounts given in col 2 are the largest considered likely to be derived from a 2 g sample of the material. The expression 'no interference' in col 3 and 4 signifies that at least this amount of the ion in question may be tolerated. Interactions between different extraneous ions are not considered.

6.3 Determination

6.3.1 *Method A* - With sodium diethyldithiocarbamate.

6.3.1.1 *Reagents*

a) *Sodium diethyldithiocarbamate — 0.2 percent solution*

This solution is best prepared in small quantities at weekly intervals and should be filtered before use.

b) *Ammonium citrate 20 percent solution*

Dissolve 16 g citric acid in water and add ammonium hydroxide solution (relative density 0.880) until the solution is just acid to litmus paper. Dilute the cooled solution to 100-ml and shake it in a separating funnel with a small amount of an approximately 0.01 percent solution of dithizone in carbon tetrachloride, further quantities of this being added, if necessary, until the solvent layer remains green, blue or violet after the mixture has been shaken vigorously for 2 minutes. Separate the solvent layer and shake the aqueous layer with successive small amounts of purified carbon tetrachloride (*see* below) until the solvent remains colourless. Filter the reagent to remove droplets of the solvent.

c) *Carbon tetrachloride*

Fresh supplies of the solvent may contain carbon disulphide and should be purified as follows:

Add alcoholic potassium hydroxide solution, with shaking, until no further yellow colour develops. Allow the mixture to stand for 1 hour, wash it several time with water and treat as described below.

Used carbon tetrachloride that has accumulated from previous analysis, or new solvent that has been partly purified as above, shall be shaken with successive portions of concentrated sulphuric acid until the acid layer remains colourless. Then shake the solvent with powdered calcium hydroxide until evaporation of a test sample on litmus paper shows that it is free from acid. Finally filter it through Whatman filter paper No. 1 and distil it.

6.3.1.2 *Procedure*

Place 10 ml of ammonium citrate solution and a few drops of phenolphthalein indicator in a 100-ml separating funnel, add the ash solution (*see* **6.1**) or a suitable aliquot containing not more than 150 µg of copper, and dilute the mixture to about 30 ml with water. Gradually run in ammonium hydroxide solution of any convenient strength until a permanent faint pink colour is obtained, cool the solution and add 2 ml of sodium diethyldithiocarbamate solution. Extract the brown precipitate by shaking with 20 ml of carbon tetrachloride.

If the presence of lead, mercuric, zinc or zirconium ions is suspected, add further quantities of sodium diethlydithiocarbamate solution at this point until the depth of colour of the carbon tetrachloride layer no longer increases. Add small amounts of the reagent in the two subsequent extractions to ensure that all the copper has reacted. Do not carry out the extractions in strong day light and shield the extracts from light whenever possible.

Run the lower (solvent) layer into a 50-ml graduated flask and re-extract the aqueous layer with two successive portions (each 10 ml) of carbon tetrachloride, the second of which should remain colourless Dilute the combined solvent extracts to 50 ml with carbon tetrachloride and dry by shaking with 1 g of anhydrous sodium sulphate The solution is stable for at least 24 hours unless exposed to strong daylight Treat the 'blank' solution prepared as described in **6.1**, or an aliqout portion corresponding to that used for the actual test, exactly as described above Decant the dry solutions in to the 1 cm or 4 cm cells of a Spekker absorptiometer and measure their optical densities with the use of Ilford 601 violet filters Maximum absorption occurs at a wavelength of approximately 440 nm Obtain the copper contents from a calibration graph in which the optical densities of extracts prepared as above from aqueous solutions containing different known amounts of copper are plotted against the copper contents of the corresponding aqueous solutions Prepare the latter by suitably diluting a more concentrated solution of copper sulphate

Table 1 Effects of Extraneous Ions

(*Clause* 6 2 1)

Extraneous Ion (1)	Amount mg (2)	Sodium Diethyldithiocarbamate (Method A) (3)	Dithizone (Method B) (4)
Aluminium	15	No interference	No interference
Antimonous	150	No interference	No interference
Antimonic	150	No interference	Interferes at all concentrations (*see* Note 1)
Borate	100	No interference	No interference
Calcium	50	No interference	No interference
Chromic	75	Interferes at concentrations above 1 mg chromium (*see* Note 2)	No interference
Chromate	75	No interference	Interferes at all concentrations (*see* Note 1)
Cobaltous	1	Interferes at all concentrations	No interference
Ferric	25	No interference	Interferes at concentrations above 20 mg iron (*see* Note 3)
Lead	15	More reagent A1* required	No interference
Magensium	20	No interference	No interference
Manganous	15	Interferes at concentrations above 1 mg manganese (*see* Note 4)	No interference
Mercuric	5	More reagent A1* required	Interferes at all concentrations
Phosphate	500	No interference	No interference
Sodium	30	No interference	No interference
Stannic	500	Interferes at concentrations above 5 mg tin (*see* Note 2)	Interferes at concentrations above 5 mg tin (*see* Note 5)
Titanium	40	No interference	Interferes at concentrations above 10 mg titanium (*see* Note 5)
Zinc	80	More reagent A1* required	No interference
Zirconium	15	More reagent A1* required	No interference (*see* Note 5)

* Sodium diethyldithiocarbamate (0 2 percent)

NOTES

1 Reagents destroyed by oxidation

2 Hydroxides of the extraneous ions are precipitated and difficulties arise if the amount of the precipitate is too large

3 Amounts of ferric iron up to 25 mg may be present if 4 ml of the buffer solution is used [*see* **6.3.2.1** (b)]

4 Amounts of manganese between 5 mg and 15 mg give the extract a pink colour Within this range the absorption varies little with the manganese content and is about the same as that produced by 3 µg of copper

5 Phosphates of the extraneous ions are precipitated and difficulties arise if the amount of the precipitate is too large

Any other absorptiometer or colorimeter may be used, or the colours of the extracts may be compared visually, in tubes of uniform dimensions, with those of a series of extracts freshly prepared from solutions of known copper content. These alternatives may, however, affect the maximum permissible amount of copper in the solution taken for extraction.

6.3.2 *Method B* – With diphenylthiocarbazone (dithizone).

6.3.2.1 *Reagents*

a) *Dithizone, 0.002 percent solution in purified carbon tetrachloride* - Prepare the solution daily and purify as follows:

Shake 10 ml of a 0.02 percent stock solution of dithizone in purified carbon tetrachloride in a separating funnel with 20 ml of water containing a drop of dilute ammonium hydroxide solution. Reject the yellowish-brown solvent layer and shake the aqueous layer with a small amount of carbon tetrachloride, which is also rejected. Add 100 ml of carbon tetrachloride and then sufficient dilute hydrochloric acid to precipitate all the dithizone from the aqueous layer. Dissolve the precipitate in the solvent by shaking and run the solution off through a plug of loose cotton wool inserted in the stem of the funnel to remove droplets of water.

If stored in a stoppered vessel in a cool, dark place the reagent is sufficiently stable for one day's work. Under similar conditions the 0.02 percent stock solution may be kept for about a week.

b) *Buffer solution*

Dissolve 75 g citric acid and 19 g anhydrous sodium dihydrogen phosphate in water. Dilute the mixed solution to 250 ml and purify it exactly as described for the ammonium citrate solution.

c) *Tropaeolin* 00, 0.1 *percent aqueous solution*

Dissolve 0.1 g of the solid in 100 ml of water.

6.3.2.2 *Procedure*

Place 2 ml of the buffer solution in a 50 ml separating funnel, add the ash solution (*see* **6.1**) or a suitable aliquot containing not more than 10 µg of copper, and dilute the mixture to about 20 ml with water. Add ammonium hydroxide solution (relative density 0.880) gradually until the mid hue of the indicator is reached, cool the solution and add 10.0 ml of dithizone solution by means of a pipette. Shake the funnel steadily for 2 minutes (about 240 strokes). The colour of the lower (solvent) layer should now be green, blue or violet. If it is violet-red add a further quantity (10.0 ml) of dithizone solution and repeat the shaking.

Run the solvent layer into another separating funnel and shake for 30 seconds with 10 ml of 0.1 N hydrochloric acid (*see* Note 1). If it is then still red reject it and repeat the determination with a smaller aliquot of the original solution. Otherwise, draw it off through a small tuft of cotton wool inserted in the stem of the funnel to remove droplets of water and collect it in a 1 cm cell of the Spekker absorptiometer. Treat the 'blank' solution, prepared as described in **6.1**, or an aliquot portion corresponding to that used for the actual determination exactly as described above.

Measure the optical densities of the extracts with the use of green filters. Maximum absorption of the copper complex occurs at about 550 nm, but it is preferable to make measurements at 510 nm where the absorption of the unchanged dithizone is at a minimum. The difference between the optical densities of the 'test' and 'blank' extracts is used to obtain the copper content directly from a calibration graph constructed as follows.

Extract a series of solutions containing different measured amounts of a standard solution of copper sulphate as above and measure the optical densities of the extracts. Subtract from each value the optical density of the extract from a similar solution containing no added copper and plot the differences against the copper contents of the original solutions. These differences are substantially independent of the concentration of the dithizone solution within the range 0.001 5 percent to 0.002 5 percent.

Any other absorptiometer may be used, or the colour of the extract and those of extracts prepared similarly from a series of aqueous solutions containing known amounts of copper may be compared visually in small stoppered tubes of uniform dimensions. It is not possible to make the comparison in colorimeters of the Duboseq type. The colours are stable for few hours if the solutions are protected from light.

NOTES

1 If zinc is known to be absent, or if the amount present is less than about 1 mg, the acid wash may be omitted. Zinc tends to react more rapidly than copper and when large amounts of zinc are present, the solvent layer may become bright red. Copper is extracted completely, however, by a solution of the zinc complex, the copper complex being unaffected by the acid wash which removes the zinc from the solvent layer.

2 The success of this method depends on scrupulous cleanliness. All apparatus shall be washed, first with dilute hydrochloric acid and then with distilled water immediately before use.

7 ESTIMATION OF IRON (Fe)

7.1 Destruction of the Organic Matter

7.1.1 *Method 1 - Wet Ashing*

Follow the procedure described in **6.1.1**. This method is preferable to Method 2 particularly when the amount of iron is small or when siliceous substances are present.

7.1.2 *Method 2 - Dry Ashing*

Determine the mass of the test specimens before ashing, place in a porcelain crucible and impregnate with a 5 percent solution of magnesium nitrate at the rate of 1 ml per gram of test specimen. Alcohol may be used to facilitate the impregnation of poorly wettable materials. Take care to ensure that the inner surface of the crucible has not been damaged or roughened, as this may lead to loss of iron by combination with the glaze. Prepare dry ash by the method prescribed in IS 199:1989 (*see* section D/25) and dissolve the ash by treating it with 1 ml of concentrated hydrochloric acid and evaporate to dryness on a water-bath; dissolve the residue in dilute hydrochloric acid. Prepare a 'blank' by evaporating 1ml of concentrated hydrochloric acid with the appropriate quantity of magnesium nitrate solution.

7.2 Selection of Colorimetric Method

7.2.1 The mercaptoacetate method (Method A) is relatively simple, but is limited in its application by the interference of certain other ions, as shown in Table 2. The oxine method (Method B) is more tedious, but may be applied in presence of nearly all the ions shown in the table without preliminary separations. It is also slightly more sensitive than the mercaptoacetate method.

The amounts given in col 2 of the Table 2 are the largest likely to be derived from a 2 g sample of the material: the expression 'None' in col 3 and 4 signifies that at least this amount of the ion in question may be tolerated under the conditions set out in **7.3.1** and **7.3.2**. Interactions between different extraneous ions are not considered.

7.3 Determination

7.3.1 *Method A* – with mercaptoacetic acid.

7.3.1.1 *Reagents*

a) *Mercaptoacetic acid*, 10 percent

b) *Ammonium chloride or ammonium sulphate*, free from iron.

If a suitably iron free sample is not available a 20 percent *m/v* solution may be purified as follows.

Treat the solution with oxine solution until an excess appears to be present (1 ml to 2 ml is usually sufficient) and adjust with dilute ammonium hydroxide until just acid to litmus paper. Extract the solution with successive portions of chloroform until the extract is colourless and finally filter it to remove suspended solvent.

7.3.1.2 *Procedure*

Transfer the acid solution from the ashing procedure or an aliquot containing not more than 200 µg of iron, to a 50 ml volumetric flask. Add ammonium chloride or ammonium sulphate so that the amount of ammonium salts finally present in the neutralized solution will be 3 to 5 g. Add 1 ml mercaptoacetic acid solution, followed by ammonium hydroxide solution (relative density 0.880) until a red colour develops. Add further 1 ml of ammonium hydroxide. Cool the solution and dilute to 50 ml. It is stable for at least 2 hours if free from copper.

Treat the 'blank' solution, prepared as described in **7.1** or an aliquot portion corresponding to that used for the actual determination exactly as described above.

Decant the solutions into 4 cm cells of the Spekker absorptiometer and measure their optical densities with the use of Ilford 604 green filters. Maximum absorption occurs at a wave-length of approximately 530 nm. Obtain the iron contents by reference to a graph, in which the optical densities of standards prepared as above from solutions containing known amounts of iron are plotted against their iron contents.

Table 2 Effects of Extraneous Ions

(*Clause* 7 2 1)

Extraneous Ion (1)	Amount (mg) (2)	Mercaptoacetate (Method A) Interference (3)	Oxine (Method B) Interference (4)
Aluminium	15	None up to 1 mg[*]	None with slightly modified method (*see* Note 1)
Antimonic	150	None up to 25 mg[*]	None
Antimonous	150	None up to 40 mg[*]	None
Borate	100 of H_3BO_3	None	None
Calcium	50	None	None
Chromic	75	Slight at 0 1 mg[*]	None with slightly modified method (*see* Note 1)
Cobaltous	1	None up to µg[†]	None
Cupric	35	Amounts greater than 10 µg cause fading	Upper light 3 mg (*see* Note 2)
Lead	15	Amounts greater than 10 mg cause high results	None
Magnesium	20	None	None
Manganous	15	None	None
Mercuric	5	None	None
Molybdate	1 000 of Mo	None up to 1 mg[†]	Negligible up to 20 mg Mo
Phosphate	500 of H_3PO_4	Recovery above 99% percent at 500 mg	None
Sodium	30	None	None
Stannic	500	None Up to 15 mg[*]	None up to 100 mg by modified method (*see* Note 3)
Titanic	40	Slight at 0 1 mg[*]	None by modified method (*see* Note 3)
Tungstate	1 000 of W	None up to 10 mg[†]	None up to 100 mg
Vanadate	1 000 of V	None up to 1 mg[†]	Interferes at all concentration
Zinc	80	None	None
Zirconyl	15 of Zr	Slight at 0 1 mg[*]	Retards extraction of iron (*see* Note 4)

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[*] These ions interfere because they form insoluble hydroxides It should be noted that many of them form complexes with mercaptoacetic acid and when large amounts are present this may result in bleaching of the colour of the iron complex Clarity of the solution is not, therefore a trustworthy indication of non-interference The amounts quoted are the largest with which quantitative recovery of iron may be obtained

[†] These ions interfere by forming coloured complexes with the reagent

NOTES

1 When aluminium or chromium is present, low results are obtained if much heat is developed during the preliminary neutralization in presence of tartrate In the case the solution is roughly neutralized with ammonium hydroxide acidified with 5 ml of sulphuric acid, and cooled before the sodium tartrate is added

2 Copper oxinate is normally extracted along with the iron and separated by washing with the cyanide buffer solution If the amount of copper exceeds 3 mg however the precipitated oxinate will not dissolve completely in chloroform and the recovery of iron may be low

3 If tin or titanium is present the ash solution shall be kept strongly acid and not be diluted until immediately before the analysis Otherwise, hydrolysis may cause the chloroform layer to emulsify even though no visible precipitate is present If more than 10 mg of the metals is present a portion will be extracted as oxinate and appear in the chloroform layer In this case the first extract is run without filtration into a separating funnel containing 50 ml of 0 1 N sulphuric acid and shaken until the solvent layer becomes colourless 1 ml of sodium tartrate solution 1 ml of oxine solution and 3 ml of ammonium chloracetate solution are added to the contents of the funnel which is then shaken for 1 minute Only the oximates of iron and copper return to the solvent layer which is then drained into potassium cyanide solution as above

4 The zirconyl ion causes low results if heat is developed in the preliminary neutralization in presence of tartrate It is also too readily hydrolysed to enable the modification described for aluminium or chromium to be employed Further it appears to retard the extraction of iron If it is desired to avoid separating this ion recoveries of iron of the order of 95 percent may be obtained by adding ice to the solution before the preliminary neutralization and by shaking with the chloroform for 5 minutes

The standards may be prepared by dilution of a solution of ferric alum in 0.1 N sulphuric acid.

Any other absorptiometer or colorimeter may be used, or the samples may be compared visually with freshly prepared standards in tubes of uniform dimensions. These variations may, however, affect the maximum permissible amount of iron in the solution

7.3.2 *Method B* – With 8-hydroxyquinoline (oxine).

7.3.2.1 *Reagents*

a) *Sodium tartrate 2M* – Free a solution containing 460 g of the hydrated salt per litre from iron as described for reagent in **7.3.1.1** (b).

b) *Ammonium chloracetate 4M* – Dissolve chloracetic acid (380 g) in water and neutralize with ammonium hydroxide (relative density 0.880) the solution being cooled during the process to reduce hydrolysis. Free the solution from iron as described above for reagent in **7.3.1.1** (b).

c) *Oxine, 5 percent solution in 2M acetic acid.*

d) *Potassium Cyanide buffer* – Prepare the solution, which has a *p*H value of 8.5 by dissolving 0.5 g of potassium cyanide in 100 ml of 0.06 N hydrochloric acid. Store this in well stoppered bottles and reject it if it becomes discoloured.

e) *Chloroform* - This may be recovered by shaking first with successive portions of concentrated sulphuric acid until the acid layer remains almost colourless, then with an excess of calcium hydroxide, filtering any finally distilling. Add alcohol at the rate of 1 percent by volume to the distillate.

f) *Methyl orange*, 0.1 percent.

7.3.2.2 *Procedure*

Transfer the acid solution from the ashing procedure, or an aliquot portion containing not more that 250 µg of iron, to a 250 ml conical flask and dilute to 30 ml. Cover the flask by a light shield (*see* Note 2). Add 1 ml sodium tartrate solution and a few drops of methyl orange indicator and neutralize the solution with concentrated ammonium hydroxide solution. The end point is easily observed, without removal of the shield, by holding the flask a short distance above a white tile and looking down the neck. Cool the flask rapidly in running water, the shield being removed temporarily and exposure to strong daylight avoided; make any necessary adjustment of the *p*H with dilute acid or alkali. Add 2.5 ml 2 N sulphuric acid, 1.0 ml oxine solution and 3.0 ml ammonium chloracetate solution in that order with intermediate mixing, the solution being transfered to a 100 ml separating funnel and diluted to about 50 ml. Add 25.0 ml chloroform and shake the contents of the funnel steadily for 2 minutes (about 300 cycles).

Drain the solvent layer through a tuft of cotton wool inserted in the stem of the funnel and collect it in another 100 ml separating funnel containing 20 ml of potassium cyanide solution. Shake this funnel for 1 minute and drain the solvent layer through another cotton plug directly into a cell of the Spekker absorptiometer. Measure its optical density with the use of I ford No.602 blue filter, maximum absorption being at about 470 lm. The extract is stable for at least 1 hour evaporation if prevented.

Treat the 'blank' solution, prepared as in **7.1**, or an aliquot corresponding to that used for the actual determination, exactly as above.

Determine the iron content by reference to a calibration graph prepared as follows :

Dilute measured amounts of a standard solution of ferric alum in 0.1 N sulphuric acid with water to 50 ml and treat as described above, omitting neutralization to methyl orange. If a freshly prepared solution of oxine is used, the 'blank' should show only a very small absorption which is calculated as iron by assuming the graph near the origin to be linear. Add this amount of iron to each standard when the graph is plotted and extrapolate the curve to the origin. Any other absorptiometer may be used, or the extracts may be compared visually with freshly prepared standards in tubes of similar dimensions. These variations may, however, affect the maximum amount of iron that may be present.

NOTES

1 All apparatus should be rinsed with dilute hydrochloric acid and then with water before use. Care should be taken that no acid remains round the stop cocks of separating funnels, and unbuffered solutions should not be placed in the funnels.

2 Ferric ions in faintly acid solution containing tartrate are reduced by light. Suitable light shields in the form of truncated cones may be

made from black paper. They should cover the sides of the flask completely and should be loose enough to project about 2 cm below the base when the flask is lifted. After tartrate has been added the shields should not be removed (except for the brief interval while the flask is cooled) until the chloracetate has been added.

8 ESTIMATION OF MANGANESE (Mn)

8.1 Destruction of the Organic Matter

8.1.1 *Method 1 – Wet Ashing*

This method is preferable to Method 2, particularly when siliceous substances are present. Follow the procedure described in Annex A and prepare a 'blank' by evaporating appropriate quantities of the acids to about the same volume as that of the residue from the combustions. Add 0.1 ml of 5 percent sodium sulphite solution to the diluted residues before they are boiled to expel chlorine. This dissolves traces of manganese dioxide formed during the reaction. Filter off any silica or lead sulphate before proceeding with the analysis.

8.1.2 *Method 2 – Dry Ashing*

Use crucibles, preferably porcelain, which have not become roughened on the inner surface and, before igniting, impregnate the sample with a 5 percent solution of magnesium nitrate [$Mg(NO_3)_2.7H_2O$] at the rate of 1 ml/g. If necessary, use alcohol to assist penetration. These precautions reduce the possibility of loss of manganese by combination with the glaze of the crucible. Ash the sample as described in IS 199:1989 (*see* Section D/25). Dissolve the ash by heating it with 1 ml to 2 ml of concentrated hydrochloric acid, add 2 ml of 1:1 sulphuric acid solution, evaporate and, in order to expel chlorides, heat until fumes of sulphuric acid are evolved. If Method B is to be used the hydrochloric acid solution may be used directly. Filter off any silica or lead sulphate before proceeding with the analysis. Prepare a blank by evaporating to fuming point a mixture of the appropriate quantities of magnesium nitrate solution, concentrated hydrochloric acid and 1:1 sulphruic acid.

8.2 Selection of Method

8.2.1 The formaldoxime method (Method B) is about five times as sensitive as the periodate method (Method A), but the latter is some what simpler. The choice may be governed by the amount and nature of other substances present. The maximum amounts of various ions that are likely to be derived from a 2 g sample of textile material are given in Table 3. The effects of these ions on the two methods under the conditions detailed in 8.3 are summarized in col 3 and 4, the expression 'No interference' signifying that at least the stated amount of the ion in question may be tolerated.

8.3 Determination

8.3.1 *Method A – With Potassium Periodate*

Remove any interfering ions as detailed in the notes and place the prepared sample solution or an aliquot containing not more that 400µg of manganese in a 100 ml conical flask. Add sulphuric acid until a total volume of 6 ml of concentrated acid is present and dilute to about 40 ml with water. Add 0.25 g of potassium metaperiodate (KIO_4), heat the solution to boiling and keep it at, or preferably slightly below, the boiling point for 1 hour. Keep the flask covered in order to minimize evaporation. Cool the flask, protecting the contents from dust, transfer the solution to a 50 ml graduated flask and dilute to volume. Measure the optical density of the solution on a Spekker absorptiometer using 4 cm cells and Ilford No.604 filters (green). The maximum absorption of the solution lies at about 525 nm. The colour is very stable.

Treat the blank solution similarly.

Prepare a calibration curve by treating measured volumes of a standard solution of managanese sulphate exactly as above and plotting the optical densities against the maganese contents of the solutions.

Any other absorptiometer may be used to measure the optical densities but this changed may affect the maximum permissible concentration of manganese.

8.3.2 *Method B – With Formaldoxime*

8.3.2.1 *Reagents*

a) Formaldoxime solution – Dissolve 9 g of analytical reagent quality hydroxylamine hydrochloride in water, add 4.5 ml of 40 percent formaldehyde solution and dilute to 100 ml. The solution is stable for several weeks.

Table 3 Effects of Extraneous Ions

(*Clause* 8 2 1)

Extraneous Ion (1)	Amount mg (2)	Periodate (Method A) (3)	Formaldoxime (Method B) (4)
Aluminium	15	No interference	No interference
Antimonic	150	Interferes (*see* Note 1)	No interference
Borate	100	No interference	Interferes (*see* Note 4)
Calcium	40	No interference	No interference
Chromic	75	Interferes (*see* Note 2)	Interferes (*see* Note 2)
Cobaltous	1	Slight interference (1 mg Co = 2μg Mn)	Slight interference (1mg Co=1 5μg Mn)
Cupric	35	Slight interference (*see* Note 3)	Slight interference (*see* Note 5)
Ferric	25	Slight interference (*see* Note 3)	No interference*
Lead	15	No interference	No interference
Magnesium	20	No interference	No interference
Mercuric	5	No interference	No interference
Molybdate	500 (Mo)	No interference	No interference
Nickel	1	No interference	No interference
Phosphate	500	No interference	No interference (*see* Note 6)
Sodium	30	No interference	No interference
Stannic	500	Interferes (*see* Note 1)	No interference*
Titanic	40	No interference	No interference*
Tungstate	700 (W)	Interferes (*see* Note 1)	Interferes (*see* Note 1)
Vanadate	300 (V)	Interferes above 10 mg	No interference*
Zinc	80	No interference	No interference
Zirconyl	18	No interference	No interference

* These ions, ferric and vanadate, interfere even at low concentrations, but they are removed by extraction of their cupferron complexes

NOTES

1 Tungsten forms a precipitate of tungstic acid that cannot be filtered from the original solution

Antimony and tin form precipitates when the solution is boiled

Separate manganese from tungsten by the procedure in Note 2

Remove antimony and tin by passing hydrogen sulphide into the hot solution (acidity 2N to 3N) until precipitation is complete filter and evaporate the filterate to a convenient volume before proceeding with the analysis Quantities of antimony and tin less than 10 mg do not require separation

2 Chromium forms coloured chromate ions in Method A and coloured tartrate complexes in Method B It shall be entirely absent for Method A and only about 1 mg may be present in Method B

Separate manganese by adding about 3 mg of ferric ion to the dilute sample solution (100 ml) followed by 3 ml of 100 volume hydrogen peroxide and a slight excess of sodium hydroxide solution Heat the solution to boiling and boil until effervescence cease Filter hot and wash the precipitate free from chromate Dissolve the precipitate in dilute sulphuric acid containing 0 1 ml of 5 percent sodium sulphite solution boil out the excess of sulphur dioxide and determine the manganese by either method

3 Copper and iron interfere by virtue of the colours of their solutions The absorption of 35 mg of copper is equivalent to about 2 μg of manganese Separate copper as sulphide (*see* Note 1) or as described in Note 5

The absorption of 25 mg of iron (*see* 8.3) is equivalent to about 2μg of manganese If much iron is present add 2 ml of phosphoric acid (relative density 1 69) to the sample solution before adding the potassium periodate The absorption due to the iron will then be negligible

4 Borate ions react with the formal doxime Use 4 ml of a freshly prepared formaldoxime reagent five times as concentrated as that specified if the presence of borate is suspected

5 The presence of more than about 5 mg of copper tends to cause low recoveries of manganese Separate the copper by adding excess of sodium diethyldithicarbamate solution after extracting the iron as described under Method B and continuing to extract with portions of methylene chloride until no further brown colour is removed

6 Phosphate interferes by producing a precipitates in alkaline solution if appreciable amounts of lead, clacium or magnesium are present The quantities of these metals or of phosphate normally found in textiles cause no trouble

Remove lead as sulphate before beginning the analysis

If calcium is present add sufficient sulphuric acid to the original solution to ensure that the concentration of ammonium salts in the final solution will be 20 percent to 25 percent This will retain a considerable amount of calcium phosphate in solution

If magnesium is present, add 2 g of analytical reagent quality sodium pyrophosphate immediately before making the solution alkaline

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b) Tartaric acid solution – 30 g of analytical reagent quality acid in 100 ml.

c) Cupferron solution – 10 g of Cupferron in 100 ml of water. Prepare freshly and filter before use.

d) Saturated bromine water.

e) Methyl orange – 0 05 percent solution in water.

f) Zinc cyanide solution – Dissolve 10 g of analytical reagent quality potassium cyanide in 50 ml of water, and 12 g of analytical reagent quality zinc sulphate ($ZnSO_4.7H_2O$) in 50 ml of water. Mix and add sufficient concentrated ammonium hydroxide to dissolve the precipitate which forms. A small precipitate may form on keeping the solution; decant the supernatant liquid before use

g) Methylene chloride – Recover used solvent by distilling it in presence of about one-tenth its volume of 10 percent soidum hydroxide solution

h) Manganous sulphate solution – Dissolve 2.042 g of manganous sulphate ($MnSO_4.4H_2O$) in water, add 1 ml of concentrated sulphuric acid and dilute to 400 ml. This solution contains approximately 1 mg of manganese per millilitre. Standardize as follows:

Pipette 20 ml of solution into 100 ml of M sulphuric acid, add 1 g of sodium bismuthate, and allow to stand for 5 min with occasional shaking. Filter through a sintered glass (G4) filter or asbestos-padded Gooch crucible, rinse the residue with M sulphuric acid until free from permanganic acid and titrate the filtrate with freshly standardized ferrous sulphate solution: 1 ml 0.1 N reductant = 1.099 mg of Mn. Dilute this solution as required immediately before use.

8.3.2.2 *Procedure*

The procedure allows for the removal of the interfering elements iron, tin, titanium and vanadium by extraction of their cupferron complexes and for the masking of small quantities of copper, cobalt and nickel with cyanide. Remove any other interfering elements as detailed in the Notes.

Place the prepared sample solution or an aliquot containing not more than 75 µg of manganese in a separating funnel. Adjust the volume to about 25 ml and the sulphuric acid content to at least 3 N (the total acidity should not exceed 6N). Cool if necessary, add 1 ml of cupferron solution and extract with 10 ml of methylene chloride. Repeat this procedure until the addition of cupferron produces only a slight precipitate of the free reagent[1], than extract with one further 10 ml portion of methylene chloride[2].

Transfer the aqueous solution to a suitable conical flask, rinsing the funnel with a minimum of water and add 1 ml of 60 percent perchloric acid if the solution does not already contain this acid. Evaporate the solution until fumes of perchloric acid are evolved and all organic matter has been destroyed[3]. Cool, add 20 ml of water, boil for a few minutes to remove chlorine and again cool. Add not more than 0.05 ml of methyl orange solution and 1 ml of tartaric acid solution, and neutralize with concentrated ammonium hydroxide solution.

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[1] The following complexes may be extracted ferric (brown), molybdate (white) stannic (white) titanic (yellow), vanadate (dark brown), zirconyl (pale yellow) Increase the initial addition of cupferron until in excess if much metal is present

[2] If copper is present in quantity proceded as described in Note 5 under Table 3 at this point

[3] The amount of organic matter remaining is very small and the reaction is without hazard The organic matter may be destroyed by prolonged digestion with sulphuric acid alone if preferred

[4] Wide-range indicator paper may be used as external indicator if preferred

[5] *See* Note 4 under Table 3

Add 3 ml of M sulphuric acid and 0.1 ml of bromine water to destroy the indicator4). Cool, add 2 ml of zinc cyanide solution, 1 ml of formaldoxime solution5) and 4 ml of ammonium hydroxide (relative density 0.880). Transfer the solution to a 50 ml graduated flask and dilute to volume. Remove a few millilitres of the solution, shake the remainder vigorously and after an interval of 30 minutes measure the optical density of the solution on a Spekker absorptiometer with 4 cm cells and Ilford No.602 filters (blue). The maximum absorption of the solution lies at about 460 nm. The colour is stable for at least 4 hours.

Prepare a calibration curve as follows:

Dilute measured amounts of a suitable standard solution of manganous sulphate to about 40 ml. Add 1 ml of tartaric acid, 2 ml of zinc cyanide, 1 ml of formaldoxime and 3 ml of ammonium hydroxide (relative density 0.880) solution. Measure the optical densities after 30 minutes and plot them against the manganese contents of the solutions.

Any other absorptiometer may be used to measure the optical densities, but this change may alter the maximum permissible concentration of manganese.

9 ESTIMATION OF CHROMIUM (Cr)

9.1 Destruction of the Organic Matter

9.1.1 *Method 1 - Wet Ashing*

This method is preferable to Method 2, particularly when the amount of chromium is small or when siliceous substances or large amounts of other ions are present. The procedure is described in Annex A, but it is esential to use sufficient sulphuric acid to cover the bottom of the flask at all times (*see* Note). The necessary amount is 2 ml for 150 ml flasks and the same amount suffices for 250 ml flasks if the bottoms are truly flat.

At the end of the reaction heat the flask strongly with the neck extension still in place. When the perchloric acid has been expelled the residual acid ceases to boil and changes from yellow-green to colourless. It is not necessary to expel every trace of perchloric acid. Dilute the residue boil it until free from chlorine, then cool and neutralize it with concentrated ammonium hydroxide solution, methyl orange (0.05 ml of a 0.1 percent solution) being used as an indicator. Re-acidify the solution with 5 ml of 2 N sulphuric acid and adjust it to a final volume of about 30 ml. Prepare a 'blank' by volatilizing nitric and perchloric acids from an appropriate mixture and treating the residual sulphuric acid as described above.

NOTE — The occurrence of bare patches leads to loss of chromium, possibly by volatilization from spray falling on the hot glass.

9.1.2 *Method 2 - Dry Ashing*

This is performed essentially as described in IS 199 : 1989 (*see* Section D/25). Determine the mass of the sample in the form of pastilles, place them in a porcelain crucible and impregnate with a 5 percent solution of magnesium nitrate at the rate of 1 ml per gram of the sample. Alcohol may be used to facilitate the impregnation of poorly wettable materials.

Ensure that the inner surface of the curcible has not been damaged or roughened, as this may lead to loss of chromium by combination with the glaze. After ignition, cover the cooled crucible with a watch glass, add 1 ml of concentrated nitric acid and 0.1 g of potassium chlorate and allow the contents to digest on a water-bath until effervescence ceases. Rinse and remove the watch glass and evaporate the contents of the crucible to dryness. Heat the residue on a water bath until it is odourless, dissolve it in 5 ml of 2 N sulphuric acid and dilute to about 30 ml. Prepare a 'blank' by evaporating the appropriate volume of magnesium nitrate solution in a crucible and treating with nitric acid and potassium chlorate as above.

9.2 Removal of Interfering Ions

9.2.1 The effects of other ions on the determination are shown in Table 4. The amounts shown in col 2 are the largest likely to be derived from a 2 g sample of textile material and the expression 'no interference' in col 3 indicates that at least this amount may be tolerated under the conditions detailed in **9.3**. The data relate to wet-ashed sampled only; the effects of dry ashing in presence of large amounts of these elements and radicals and of interactions between different ions have not been studied.

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1) If the combined content of iron and copper exceeds 1 mg, a further 1 ml of oxide should be added and the process repeated until excess oxine is present.

2) Hydrazoic acid is very volatile and irritates the mucous membrane. Inhalation of the vapour from these solutions should therefore be avoided.

Table 4 Effects of Extraneous Ions

(*Clause* 9 2 1)

Extraneous Ion (1)	Amount mg (2)	Effect (3)	Extraneous Ion (1)	Amount mg (2)	Effect (3)
Aluminimum	15	No interference	Magnesium	20	No interference
Antimonic	150	Note 1	Manganous	15	Note 4
Borate	100 (H_3BO_3)	No inteferecence	Mercuric	5	Note 1
Calcium	50	No interference	Phosphate	500 (H_3BO_4)	Note 5
Cobaltous	1	No interference	Stannic	500	Note 2
Cupric	35	Note 3	Titanic	40	Note 2
Ferric	25	Note 3	Zinc	80	No interference
Lead	15	No interference even in $PbSO_4$ Precipitates	Zirconyl	15 (Zr)	Note 2

NOTES

1 If antimony (ic) and mercury remain in solution they do not interfere, though mercury may cause low results when present during the extraction of traces of iron and copper It is usually necessary to remove the metals by the following process

The perchloric acid is not expelled at the end of the wet ashing procedure but the flask is cooled and the residue diluted The solution is made about 3 N in hydrochloric acid, boiled to dissolve antimonic compounds, if present, and diluted to a total acidity of about 1N It is then heated on a water-bath for 30 minutes while a current of hydrogen sulphides is passed through it The flask is than stoppered and cooled The solution is filtered, the filtrate being returned to the flask and evaporated to small volume After the neck extension has been replaced on the flask the perchloric acid is expelled and the preparation of the solution completed as in Method 1 (*see* **9.1**)

2 Zirconium, tin and titanium interfere because they are hydrolyzed at low acidities They may be removed by the following method

The perchloric acid is not expelled at the end of the wet-ashing procedure but the flask is cooled and the residue diluted Hydrochloric acid is added, if necessary, to assist the solution of tin and titanium compounds, the solution is boiled until free from chlorine, cooled and diluted until it contains about 10 percent by volume of concentrated acids It is transferred to a separating funnel treated with excess of a 10 percent aqueous solution of cupferron and extracted with several 10 ml portions of methylene chloride The completeness of the precipitation should be checked by adding more cupferron after the first extraction The white stannic complex is difficult to distinguish from excess of the reagent but it is less translucent than the latter

After extraction the aqueous phase is returned to the flask and evaporated to small volume The neck extension is replaced, the perchloride acid expelled and the preparation of the solution completed as in Method 1 (*see* **9.1**)

3 Amounts of iron and copper greater than 1 or 2 mg are not conveniently dealt with by the oximate extraction procedure described in **9.3**. Large amounts of copper should be separated by the method given in Note 1, and large amounts of iron by that given in Note 2

If the total amount of iron and copper in the samples is known not to exceed 10 µg the extraction of these metals as their oximates may be omitted, the neutralized and re-acidified solution being oxidized immediately Under these circumstances also, the solution from the dry ash may be treated with diphenylcarbazide without further oxidation The optical densities of the solutions should be read within a few minutes of adding the reagent

4 Manganese dioxide may be precipitated when the chromium is oxidized and cause low results when more than 1 mg of manganese is present If the solution is free from ammonium salts as much as 15 mg of manganese may be present

5 Phosphate causes precipitation of the ferric ion and only 15 mg of phosphoric acid can be tolerated or 5 mg if ammonium salts are absent By substituting potassium permanganate for ferric ammonium sulphate the full 500 mg of phosphoric acid may be tolerated

Iron and copper cause fading of the colour and variation in its hue; the procedure described in 9.3 therefore provides for the removal of small amounts of these metals.

9.3 Determination

9.3.1 *Reagents*

a) *8-hydroxyquinoline (oxine)* – 1 percent solution in 2 N acetic acid.

b) *Chloroform* – Recover this by shaking it with successive portions of concentrated sulphuric acid until the acid remains almost colourless. Shake the solvent with excess of calcium hydroxide filter and distil it. Add alcohol (1 percent by volume) to the distillate.

c) *Methylene chloride* - Recover the methylene chloride, which is used for the extraction of Cupferron complexes by shaking it with successive portions of a 10 percent solution of sodium hydroxide until the alkali remains almost colourless, and then distilling the solvent over solid sodium hydroxide.

d) *Ceric ammonium sulphate* – 0.05 N solution in 2 N sulphuric acid.

e) *Sodium azide* – 5 percent solution in water.

f) *Diphenylcarbazide* – 0.25 percent solution in equal volumes of acetone and water; this solution must be prepared daily.

g) *Ammonium sulphate* – free from iron and copper. Treat a 20 percent (*m/v*) solution of the salt with an excess of oxine solution and adjust of *p*H 5 to 6 (wide range paper) with dilute ammonium hydroxide. Extract the solution with successive portions of chloroform until the solvent remains colourless and then filter it to remove suspended solvent.

9.3.2 *Procedure*

Transfer the acid solution from the ashing process, or an aliquot containing not more than 75 µg of chromium, to a separating funnel, 0.05 ml of a 0.1 percent solution of methyl orange if required, and treat the solution with 1 ml of oxine solution. Neutralize carefully with ammonium hydroxide to the mid hue of the indicator, or until the colour of the indicator is obscured by black ferric oxinate. If the end point of the indicator is accidentally passed acidify the solution again and repeat the neutralization. Add 10 ml chloroform, shake the funnel vigorously and after the layers have separated, adjust the aqueous layer if necessary to neutrality with ammonia. Again shake the funnel vigorously for 30 seconds[1], remove the chloroform layer and extract the aqueous layer twice more with fresh 10 ml portions of chloroform. Return the aqueous layer to the conical flask (*see* Note 3 under Table 4). Acidify the solution with 5 ml of 2 N sulphuric acid, boil to expel any residual chloroform and treat while still boiling with 1 ml of feric ammonium sulphate solution, boil for a further 10 minutes and cool. Remove any solid, including manganese dioxide, by filtration and treat the clear solution with 0.2 ml of sodium azide solution[2] The solution should now be colourless. If the purple colour of permanganate or the brown colour of colloidal manganese dioxide is present warm the solution gently until the colour disappears.

Transfer the cooled solution to 50 ml graduated flask, treat with 2 ml of diphenylcarbazide reagent and dilute to volume. Treat the 'blank' solution, prepared as described in **8.1**, or an aliquot portion corresponding to that used for the actual test exactly as described above.

Shake the solutions vigorously to remove dissolved gases, transfer them to the cells of a Spekker absorptiometer and measure their optical densities with the use of Ilford 605, yellow green filters. Maximum absorption occurs at a wavelength of about 540 nm. The colour is fairly stable but fades to the extent of about 1 percent in 1 hour.

Use the difference between the optical densities of the 'test' and 'blank' solutions to obtain the chromium content of the former directly from a calibration graph constructed as follows:

Transfer different measured amounts of a standard solution of potasium dichromate to separate 50 ml volumetric flasks each containing 5 ml of 2 N sulphuric acid and dilute to about 40 ml with water. If acid ashed samples are to be used add 5 g ammonium sulphate, free from iron and copper. Add 2 ml diphenylcarbazide reagent to each flask, then dilute the contents of each to 50 ml. Plot the optical density of each solution, measured as above, against its chromium content. Make fresh calibration graphs for each batch of solid diphenylcarbazide and check the graphs periodically. Any other absorptiometer may be used, or the solutions may be compared visually with freshly prepared standards in uniform tubes, but these variations may affect the maximum permissible amount of chromium in the sample.

10 ESTIMATION OF ZINC (Zn)

10.1 General

10.1.1 The dithizone method has been adopted for this estimation. According to this method, the test sample is boiled in dilute hydrochloric acid for 30 minutes in an Erlenmeyer flask, the contents cooled, filtered and washed with water, the filtrate and washings yielding a test solution. An aliquot of this solution containing approximately 1 mg of zinc per 100 ml of test solution is treated with acetate buffer solution (*p*H 4.75) and sodium thiosulphate solution or with potassium cyanide solution and extracted with dithizone to yield a bright red extract. This extract is compared against standard zinc solution treated exactly like the aliquot of the test thiosulphate.

10.1.2 In order to prevent interference due to ions of copper, mercury, lead and cadmium, the procedure provides for the use of sodium thiosulphate solution at *p*H 4.75. Next to these interfering metallic ions, cobalt and nickel are the other two important metals; when one or both of them are present the estimation has to be repeated and the interference due to one or both of them prevented by the use of potassium cyanide solution in place of sodium thiosulphate.

10.2 Destruction of the Organic Matter

10.2.1 Follow the procedure as described in **6.1.1** or **7.1.2**.

10.3 Reagents

10.3.1 *Acetate Buffer Solution of p*H 4.75

Prepared by mixing equal volumes of dilute sodium acetate solution (2 N) and dilute acetic acid (2 N). The solution should be shaken well with 3 or 4 drops of dithizone solution (*see* **10.3.7**) to remove interference due to metallic ions, if any, and filtered through a moistened filter paper to remove drops of carbon tetrachloride.

10.3.2 *Sodium Thiosulphate Solution*

Prepared by dissolving sodium thiosulphate ($Na_2S_2O_3.5H_2O$) in water to yield a 25 percent (*m/v*) solution.

10.3.3 *Dilute Ammonia*

Prepared by diluting ammonia (sp.gr 0.9) in water to yield at 1:1 (by volume) solution.

10.3.4 *Potassium Cyanide Solution*

Prepared by dissolving potassium cyanide in water to yield a 5 percent (*w/v*) solution.

10.3.5 *Dilute Hydrochloric Acid* — approximate 2 N.

10.3.6 *Sodium Acetate Solution* — approximate 2 N.

10.3.7 *Dithizone Solution*

Prepared by dissolving dithizone $H_5C_6N{=}N{-}C(S)NHNHC_6H_5$ in carbon tetrachloride to yield a 0.001 percent (*m/v*) solution (*see* **6.4.4**).

10.3.8 *Sodium Sulphate* - solid, anhydrous.

10.3.9 *Standard Zinc Solution*

Prepared by dissolving zinc (30 mesh) in dilute hydrochloric acid (0.1 N) to yield a 0.01 percent (*m/v*) solution, taking 10 ml of the solution and diluting with water to exactly 100 ml to yield ka 0.001 percent (*m/v*) solution. One millilitre of this solution contains 0.01 mg of zinc (Zn).

10.4 Procedure

10.4.1 From the test solution prepared as in **10.2.1**, choose an aliquot containing approximately 1 mg of zinc per 100 ml of solution (making rough estimations on different known quantities of the test solution, if necessary) transfer (*see also* **10.4.5**) it to a 25 ml separating funnel, add 5 ml of acetate buffer solution and 1 ml of sodium thiosulphate solution (*see* Note); mix with 5 ml of dithizone solution and shake well for 2 minutes. Allow the contents of the separating funnel to settle into two layers and when the lower of the two layers thus formed is free from water droplets, dry the stem of the funnel with a piece of filter paper rolled round a thin glass rod and run the lower layer (extract) into a 25-ml volumetric flask avoiding exposure to direct sunlight. Keep the flask well stoppered.

NOTE — When appreciable amounts of cobalt or nickel or both are present, add instead of acetate buffer and sodium thiosulphate solutions, enough ammonia to neutralize and enough potassium cyanide solution to dissolve the precipitate first formed, then add dilute hydrochloric acid drop by drop to bring the *p*H between 3 and 4 and adjust the *p*H to 5 to 5 5 with the addition of sodium acetate solution Use standard *p*H papers for adjusting *p*H

10.4.2 Re-extract the portion left in the funnel with 2 or 3 ml of carbon tetrachloride and shake well for 2 minutes. Allow the contents of the funnel to settle again into two layers and when the lower of the two layers now formed is free from water droplets, dry the stem of the funnel with a piece of filter paper rolled round a tin glass rod and run the lower layer into the 25 ml volumetric flask containing the extract obtained as in **10.4.1**.

10.4.3 Repeat the extraction two or three times (or until the aqueous layer in the separating funnel is free from red colour) collecting all the extracts in the same volumetric flask.

10.4.4 Dilute the total extract with carbon tetrachloride to exactly 25 ml; add 1 g of sodium sulphate and shake well.

10.4.5 Prepare a series of reference standards taking different known quantities of standard zinc solution contain approximately 1 mg or less of zinc per 100 ml of solution and treating the solutions side by side with and exactly as the aliquot of the test solution (*see* **10.4.1** to **10.4.4**).

10.4.6 Treat the 'blank' solution or an aliquot portion corresponding to that used for the actual determination exactly as described from **10.4.1** to **10.4.5**.

10.4.7 Measure the optical densities of the extracts at suitable wavelength where the absorption of the unchanged dithizone is at a minimum (510 nm). The difference between the optical densities of the 'test' and 'blank' extracts is used to obtain the zinc content directly from a calibration graph constructed as given in **10.4.8**.

10.4.8 Extract a series of solutions containing different measured amounts of standard zinc solutions and measure the optical densities of the extracts. Substract from each value the optical density of the extract from a similar solution containing no added zinc and plot the differences against the zinc contents of the original solutions. These differences are substantially independent of the concentration of the dithizone solution with in the range 0.001 5 percent to 0.002 5 percent.

NOTES

1 The success of this method depends on scrupulous cleanliness All apparatus shall be washed, first with dilute hydrochloric acid and then with distilled water immediately before use

2 The colour of the extract and those of extracts prepared similarly from a series of aqueous solutions containing known amounts of zinc may be compared visually in small stoppered tubes of uniform dimensions The colours are stable for a few hours if the solutions are protected from light

11 REPORT

The report shall include the following information:

a) Type and nature of textile being tested;

b) Amounts of copper, iron, manganese, chromium or zinc present; and

c) The type of treatment, if given to the fabric.

ANNEX A

(*Clauses* 6.1.1, 8.1.1 *and* 9.1.1)

WET ASHING OF TEXTILE MATERIALS

A-1 INTRODUCTION

A-1.1 Where destruction of organic matter in a sample of textile material is required, and the ash is not to be determined, wet ashing possesses many advantages over dry ashing.

A-2 PRECAUTIONARY NOTE

A-2.1 To avoid hazard, the conditions described must be carefully followed and any variation of extension of the method to materials other than those mentioned must be made only by fully trained operators.

A-3 PRINCIPLE

A-3.1 This method involves the controlled heating of the sample with a suitable mixture of nitric, sulphuric and perchloric acids.

A-4 APPARATUS AND REAGENTS

A-4.1 Conical Flasks – with neck extensions (*see* Note 1).

A-4.2 Hot Plate – with provision for maintaining graded surface temperatures.

A-4.3 Safety Glass Screen – advisable until the operator has had some experience of the method, and essential when working with previously untried materials.

A-4.4 Boiling Rods

A-4.5 Nitric Acid – concentrated, relative density 1.42.

A-4.6 Sulphuric Acid – concentrated, relative density 1.84.

A-4.7 Perchloric Acid – 60 percent, relative density 1.54 (*see* Note 2).

A-5 PROCEDURE

A-5.1 Place the specimen in the flask and add in the above order the requisite quantities of the three acids. After each addition, swirl the flask and allow any reaction which takes place to proceed to completion before making a further addition. Fit a neck extension to the flask, which is then placed on the cooler side of the hot plate, housed in an efficient fume cup board. Vigorous evolution of brown fumes occurs, accompanied by partial or complete solution of the sample. Cotton dissolves only slowly, and most coating materials are resistant to oxidation at this stage.

A-5.2 When the evolution of brown fumes has slackened, move the flask to the middle of the plate and allow excess of nitric acid and water to boil off gently. A gradually increasing evolution of gas, culminating in a vigorous reaction and generation of heavy white fumes, marks the action of the perchloric acid and the virtual completion of the oxidation. The reaction may be moderated, if necessary, by sliding the flask back to the cooler side of the hot plate. Charring of the reaction mixture at any stage should be rectified by swirling the flask or by adding a few drops of concentrated nitric acid.

A-5.3 Finally, move the flask to the hottest part of the plate and allow the residual acid to reflux until the walls of the flask and the lower portion of the neck have been thoroughly washed by the distillate. During this process, lift the neck extension momentarily about three times to release liquid held by capillary attraction at the junction with the flask.

A-5.4 After the flask has been cooled, rinse the neck extension with about 20 ml of water and remove it. Then boil the acids, thus diluted, for 2 minutes to expel chlorine, using a boiling rod to prevent pumping. The diluted perchloric acid possess no oxidizing properties and the solution at this stage is ready for analysis.

A-5.5 Table 1 shows the amounts of each acid recommended. The quantities given are suitable for use in 250 ml flasks unless otherwise stated. The addition of sulphuric acid produces a smoother reaction and facilitates the clearance of any charring that may occur. When the nature of the subsequent analysis renders its presence undesirable it may be replaced by an equal volume of perchloric acid, except in the few instances indicated.

NOTES

1 Conical flasks of 250 ml capacity are suitable for most purposes The neck extensions are easily made by drawing down the closed ends of 200 mm × 25 mm boiling tubes, blowing out the ends, chamfering them with a wire gauze and then flame polishing Extensions for flasks of other sizes are made from tubes of proportionate dimensions

2 The perchloric acid is pure enough for all but trace analysis, for which purpose it may be purified easily and economically by distillation as the 72 percent azeotrope under reduced pressure

3 The safety of the reaction depends upon the fact that readily oxidizable matter destroyed by the nirtic acid before the perchloric acid reaches its reaction temperature of about 140°C Addition of the acids in the order given reduces the risk of accidental ommission of the nirtic acid

DETERMINATION OF SCOURING LOSS IN GREY AND FINISHED COTTON TEXTILE MATERIALS

(*Source* : **IS 1383 : 1977**)

In the cotton textile industry, yarns and fabrics undergo treatments in the course of which extraneous matter of various types is gathered by or added to the original material which is it not scoured or is partly scoured may also contain natural impurities, such as oils, fats, waxes and pectins. Estimation of the quantity of natural impurities and extraneous matter present in the material is therefore, considered necessary. It covers two methods namely, *Mild Method* - Suitable for fabrics like cotton gauge, bandage cloth and fabrics of loose construction; and *Severe Method* - Suitable for other type of fabrics.

1 SCOPE

1.1 It prescribes two methods for determining the scouring loss (loss in mass on scouring) of grey and finished cotton textile materials.

1.2 The methods prescribed are generally applicable to grey and finished cotton textile materials wherein only starch or tamarind kernel powder or both, and water-soluble or easily removable finishing agents, such as oils, fats, and china clay have been used and which would normally be removed during the scouring process.

2 PRINCIPLE

The test specimen is taken and its moisture content is determined. Another test specimen is scoured, washed and its oven-dry mass is determined. The scouring loss is calculated on the basis of oven-dry mass of the test specimen.

3 SAMPLING

Sample shall be selected so as to be representative of the lot. Sample drawn in accordance with the procedure laid down in the specification of the material or as agreed to between the buyer and the seller shall be taken as representative of the lot.

4 APPARATUS

4.1 Soxhlet Aparatus

4.2 Drying Oven – Capable of maintaining a temperature of 105 ± 3°C.

4.3 Weighing Balance – Capable of weighing to an accuracy of 0.001 g.

5 REAGENTS

5.1 Unless specified otherwise analytical reagent grade chemicals shall be employed in test and distilled water shall be used where the use of water is intended.

5.2 Desizing Enzyme – Diastase (or other suitable enzyme).

5.3 Sodium Chloride – Solid.

5.4 Caustic Soda Solution – 2 percent (*m/v*), containing 1 percent turkey red oil Grade 2 (total fatty matter, percent by weight, Min 50 percent).

5.5 Acetic Acid Solution – 1 percent (*v/v*).

5.6 Chloroform

6 ESTIMATION OF MOISTURE

6.1 Draw from the sample (*see* **3**) at least 2 test specimens (*see* Note), each weighing approximately 3 g. Take one test specimen and weigh it accurately in a clean, dry and tared weighing bottle. Place the weighing bottle containing the test specimen in the drying oven and dry the specimen at 105 ± 3°C to constant mass. Weigh the oven-dry specimen accurately. Calculate the percentage of moisture in the test specimen, by the following formula:

$$\text{Moisture content, percent} = \frac{(a - b)}{a} \times 100$$

where

a = original mass, in g of the test specimen; and
b = oven-dry mass, in g of the test specimen.

NOTE — If the samples under test is fabric, the specimens drawn shall preferably be square in shape.

6.2 Similarly determine the moisture content in the second test specimen and take the average of the two values.

7 PREPARATION OF TEST SPECIMENS

Draw from the sample at least two test specimens each weighing about 5 g. If the sample under test is yarn, cut each test specimen, separately into pieces about 15 cm long, form into separate bundle and tie each bundle loosely round the middle. If the sample under test is fabric, trim each test specimen parallel to the directions of warp and weft and pull out, to form a fringe, 5 threads all round.

8 PROCEDURE

8.1 Method A (Severe Method)

8.1.1 Weigh accurately one test specimen drawn as in 7. Dip the specimen in a solution (weighing 20 times the mass of the specimen), containing, 5 g of diastase and 10 g of sodium chloride per litre, at 50°C and at a *p*H of 6.5 to 7.7 (*see* Notes 1 and 2). Allow the specimen to remain in the solution for 1½ hours. During this period, take it out from the desizing bath and wring it by hand four times. At the end of the period, remove the specimen, wash it thoroughly (without wringing) four times in hot and cold water successively, using 50 ml of water for each wash.

NOTES

1 The temperature and *p*H given for the desizing solution are the optimum for bacterial diastase. If any other type of desizing enzyme is used, then the temperature and *p*H should be modified to that recommended by the supplier. As many enzymatic desizing agents slowly deteriorate in storage, great care should be taken to see that the sample of desizing agent, at the time of test, is of satisfactory desizing efficiency.

2 If any doubt exists as to whether the size or finish has been completely removed, the treatment with the enzymatic desizing solution should be repeated, the specimen being again weighed after drying to constant mass at 105 ± 3°C and the percentage loss in mass again calculated. If the percentage loss in mass has increased by not more than 0.25, then it may be considered that complete desizing has been affected and the second figure be accepted as the final figure. If the percentage loss in mass has increased by more than 0 25 then the desizing treatment should be repeated until the figure for percentage loss in mass does not differ from the previous figure by more than 0.25.

8.1.2 Put the specimen in a 500 ml conical flask containing caustic soda solution weighing 20 times the mass of the specimen and boil for one hour. Add adequate quantity of water to make up for the loss during boiling. At the end of the period remove the specimen wash it thoroughly (without wringing) in hot water and dip it for 5 minutes in acetic acid solution. Finally wash (without wringing) the specimen in cold water. Dry the specimen in drying oven at 105 ± 3°C to constant mass and weigh it accurately.

8.2 Method B (Mild Method)

8.2.1 Weigh accurately one test specimen drawn as in 7. Extract the specimen for one hour with chloroform in a Soxhlet apparatus at the rate of 6 cycles per hour. Allow the chloroform to dry off in the air, and wash the specimen by alternate immersion in hot running water and wringing by hand 12 times in succession. Immerse the specimen in 0.5 percent aqueous solution of diastase (20 to 30 times the mass of the specimen) at 50°C and wring by hand repeating the process three times in succession. Finally, return the specimen to the solution and heat to 70°C. Allow the specimen to remain in the solution for 15 minutes and then wash it well in hot running water. Squeeze and dry the specimen at 105 ± 3°C and weigh accurately.

9 CALCULATION

9.1 Calculate the percentage of scouring loss by the following formula:

$$\text{Scouring loss, percent (oven-dry basis)} = \frac{\left[\left(M_1 - \frac{M_1 m}{100}\right) - M_2\right] \times 100}{\left(M_1 - \frac{M_1 m}{100}\right)}$$

where

M_1 = original mass in g of the specimen;

m = moisture content, percent (*see* **6.2**); and

M_2 = oven-dry mass in g of the specimen after treatment (*see* **8.1** or **8.2**).

9.2 Repeat the test with the remaining test specimen(s) and find out the average of all the values.

10 REPORT

The report shall include the following information:

a) Type of material:

b) Method used (A or B);

c) Scouring loss, percent; and

d) Number of test specimens tested.

DETERMINATION OF SCOURING LOSS OF RAYON FILAMENT YARN

(*Source* : **IS 11219 : 1984)**

Continuous filament viscose rayon yarn and acetate yarn commonly used of weaving or knitting are generally treated with special lubricants of sizes or gelatin during spinning. The general process of cleaning these filament yarns from the added lubricants of sizes is termed as scouring. The knowledge of loss due to scouring is very essential to arrive at the commercial mass of the lot which is an important criteria for grading of these filament yarns.

Since the quality of lubricants of size used during spinning is not high, the method given in this standard prescribes a simple mild treatment.

1 SCOPE

It prescribes a method for determining the scouring loss of viscose rayon and acetate rayon filament yarns.

2 PRINCIPLE

A known amount of sample is scoured with mild sodium carbonate solution. The loss in mass is determined and expressed as a percentage of the dry mass of the sample.

3 SAMPLING

3.1 Lot

The quantity of yarn of the same grade and from the same source delivered to a buyer against one despatch note shall constitute a lot. If the lot contains more than 200 kg of yarn, it shall be divided into sub-lots, each weighing 200 kg or less.

3.1.1 Each sub-lot shall be tested separately.

3.2 Unless otherwise agreed to between the buyer and the seller, 15 increments each approximately weighing 10 g shall be taken from different parts of a sub-lot so that a representative sample is obtained. All the increments thus collected shall be thoroughly mixed. This shall constitute the test sample.

4 PREPARATION OF TEST SPECIMENS

From the test sample, draw at least 2 specimens each weighing about 5 g accurate to the nearest mg.

5 ATMOSPHERIC CONDITIONS FOR TESTING

The test shall be conducted in prevailing atmospheric conditions.

NOTE — Since the dry masses are determined, it is not necessary to condition the sample.

6 APPARATUS

6.1 Drying Oven – Capable of maintaining a temperature of 105 to 110°C.

6.2 Weighing Bottle – with a stopper.

6.3 Weighing Balance – Capable of weighing to an accuracy up to 1 mg.

7 REAGENTS

7.1 Quality of Reagents

Unless specified otherwise, pure chemicals shall be employed in tests and distilled water shall be used where the use of water as reagent is intended.

NOTE — 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the test results.

7.2 Sodium Carbonate Solution – (2 g/1).

8 PROCEDURE

8.1 Take a test specimen. Transfer it to a tared weighing bottle. Dry the specimen at 105° to 110°C to constant mass (about 2 hours drying is sufficient) (*see* Note). Determine the oven-dry mass of the test specimen.

NOTE — For acetate rayon a drying temperature of 70-75°C shall be used and the period of drying may be prolonged to 4 hours till a constant mass is obtained. If two consecutive readings taken at an interval of 30 minutes of drying do not differ by more than 2 mg, it should be taken as constant mass.

8.2 Take the dried test specimen in a beaker containing 250 ml of 2 g/1 sodium carbonate solution. Treat the test specimen in this solution at 60-70°C for 30 minutes. After this take out the test specimen, wash it thoroughly with hot water (below 70°C) and dry it in the tared weighing bottle, as prescribed in **8.1**, to a constant mass. Determine the oven-dry mass of the treated test specimen.

NOTE — The material to liquor ratio should be 1 50

8.3 Calculate the percentage of scouring loss by the following formula:

$$S = \left(\frac{m_1 - m_2}{m_1} \right) \times 100$$

where

S = scouring loss, in percent, by mass on oven-dry basis;

m_1 = oven-dry mass, in g, of the specimen before scouring; and

m_2 = oven-dry mass, in g, of the specimen after scouring.

8.4 Repeat the procedure given in **8.1** and **8.2** with the remaining test specimen(s) and calculate the percentage of scouring loss by the formula given in **8.3**.

8.5 Calculate the average of the values obtained as in **8.3** and **8.4**.

9 REPORT

The report shall include the following information:

a) Type and grade of material; and

b) Average scouring loss, percent.

DETERMINATION OF SCOURING LOSS IN SILK TEXTILE MATERIALS

(*Source* **IS 1582:1968**)

Raw silk contains, besides sericin, some traces of fat and mineral matter. Silk may be used in raw state, and afterwards either boiled off or not, according to the purpose for which it is intended. The silk gum and other impurities are generally removed from the silk textile materials by the process of boiling. Silk textiles are boiled off by passing them through heated soap liquor and hot water.

Method of test for determining the quantity of sericin and other extraneous matter present in the material is, therefore, considered necessary. The method of test prescribed in this standard shall be used as an aid in the determination of scouring loss of silk textile materials.

1 SCOPE

1.1 It prescribes a method for determining the scouring loss of silk textile materials.

1.1.1 The method prescribed in this standard is generally applicable to silk textiles wherein only sericin and other extraneous matter which would normally be removed during the scouring or boiling process.

2 PRINCIPLE

A known amount of sample is scoured with mild soap and soda solution. The loss in weight is determined and expressed as a percentage of the dry weight of the sample.

3 SAMPLING

3.1 Sampling for Yarn

3.1.1 *Lot (Yarn)*

The quantity of yarn from the same source shall constitute the lot. If the lot contains more than 200 kg of yarn, it shall be divided into sub-lots, each weighing 200 kg or less.

3.1.2 Unless otherwise agreed to between the buyer and the seller, 15 increments each approximately weighing 10 g shall be taken from different parts of a sub-lot so that a representative sample is obtained. All the increments thus collected shall be thoroughly mixed. This shall constitute the test sample.

3.2 Sampling for Fabrics

3.2.1 *Lot (Fabric)*

The quantity of fabric manufactured essentially under uniform conditions shall constitute a lot.

3.2.2 Unless otherwise agreed to between the buyer and the seller the number of pieces to be selected from a lot shall be as given below. The pieces thus selected shall constitute the gross sample:

Lot Size	*Sample Size*
Up to 100	3
101 " 300	4
301 " 500	5
501 and above	7

3.2.3 From each piece in the gross sample about 25 g of fabric shall be taken out from at least 2 different parts. The parts shall then be cut into further smaller pieces and thoroughly mixed. The pieces thus collected shall constitute the test sample.

4 PREPARATION OF TEST SPECIMENS

From the test sample, draw at least 2 test specimens each weighing about 5 g.

5 ATMOSPHERIC CONDITIONS

The test shall be conducted in prevailing atmospheric conditions.

NOTE — Since the dry weights are determined, it is not necessary to condition the sample.

6 APPARATUS

6.1 Air Oven – Capable of maintaining a temperature of 105 to 110°C.

6.2 Weighing Bottle – With a stopper.

7 REAGENTS

7.1 Quality of Reagents – Unless specified otherwise, pure chemicals shall be employed in tests and distilled water shall be used where the use of water as reagent is intended.

NOTE — 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the test results.

7.2 Sodium Carbonate Solution – 1 percent (*w/v*).

7.3 Soap Solution – 1 percent solution (*w/v*) of neutral soap.

NOTE — Olive oil soap is suitable for this test.

8 PROCEDURE

8.1 Take a test specimen. Transfer it to a tared weighing bottle. Dry the specimen at 105 to 110°C to constant weight (about 2 hours drying is sufficient) (*see* Note). Determine the oven-dry weight of the test specimen.

NOTE — The consecutive weights taken at an interval of 30 minutes of drying should not differ by more than 2 mg.

8.2 Take the dried test specimen in a beaker. Boil it gently (*see* Note 1) for 1 hour with 150 ml of soap solution (*see* Note 2). Squeeze the test specimen and transfer it to a beaker containing 150 ml of sodium carbonate solution and boil for half an hour (*see* Notes 1 and 2). Take out the test specimen, wash it thoroughly with hot water and dry it in the tared weighing bottle to constant weight (about 2 hours drying is sufficient) in the oven. Determine the oven-dry weight of the test specimen.

NOTES

1 For very fine quality of silk, the temperature of the soap or soda solution should be 80°C.

2 The material to liquor ratio should be 1:30.

8.3 Calculate the percentage of scouring loss by the following formula:

$$S = \frac{(W_1 - W_2) \times 100}{W_1}$$

where

S = scouring loss, in percent, by weight on oven-dry basis;

W_1 = oven-dry weight, in g, of the specimen before scouring; and

W_2 = oven-dry weight, in g, of the specimen after scouring.

8.4 Repeat the procedure given in **8.1** and **8.2** with the remaining test specimen(s) and calculate the percentage of scouring loss by the formula given as in **8.3**.

8.5 Calculate the average of the values obtained as in **8.3** and **8.4**.

9 REPORT

Report the value obtained as in **8.5** as the scouring loss in percent, of the test sample.

DETERMINATION OF WATER SOLUBLE CHROMATE IN TEXTILE MATERIALS

(*Source* : **IS 5449 : 1969**)

Water soluble chromium salts are used in dyeing of wool and other textile materials. If the water soluble chromium content of finished textiles is beyond a certain limit, it may cause some skin diseases when such textiles are worn next to the skin. The limit for water soluble chromium is, therefore, specified in many material specifications. It is hoped that this standard will be useful for determining the amount of water soluble chromium (expressed as sodium chromate or potassium dichromate) in textile materials.

The methods is applicable only where the colour of the extracted dyes is destroyed by treatment with bromine.

1 SCOPE

It prescribes methods for determination of water soluble chromium (expressed as sodium chromate or potassium dichromate) present in textile materials.

2 PRINCIPLE

A specimen is extracted with water and the amount of water soluble chromium is estimated volumetrically or by comparing the colour of the extract with the colour of the standard potassium dichromate solution.

3 SAMPLING

3.1 Sampling for Fibre and Yarn

3.1.1 *Lot (Fibre on Yarn)*

The quantity of fibre of yarn from the same source shall constitute a lot. If the lot contains more than 200 kg of fibre or yarn, it shall be divided in sub-lots each weighing 200 kg or less.

3.1.2 From a sub-lot 15 increments, each approximately weighing 10 g, shall be taken from different parts so that a representative sample is obtained. All the increments this collected shall be thoroughly mixed. This shall constitute the test sample.

3.2 Sampling for Fabrics

3.2.1 *Lot (Fabric)*

The quantity of fabrics manufactured under relatively uniform conditions shall constitute a lot.

3.2.2 The number of pieces to be selected from a lot shall be as given below. The pieces thus selected shall constitute the gross sample.

Lot Size	*Sample Size*
Up to 100	3
101 to 300	4
301 to 500	5
501 and above	7

3.2.3 From each piece in the gross sample about 25 g of fabric shall be taken out from at least two different parts. The parts shall then be cut into further smaller pieces and thoroughly mixed. The pieces thus collected shall constitute the test sample.

4 CONDITIONING OF TEST SPECIMENS

Prior to test, the test specimens shall be conditioned for 24 hours to moisture equilibrium in a standard atmosphere of 65 ± 2 percent relative humidity and 27 ± 2°C temperature

5 QUALITY OF REAGENTS

Unless specified otherwise pure chemicals shall be employed in tests and distilled water (*see* IS 1070:1992 Reagent grade water (*third revision*)) shall be used where the use of water as reagent is intended.

NOTE — 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the test results.

6 FIRST METHOD

6.1 Apparatus

6.1.1 *Conical Flask*

6.1.2 *Beaker*

6.2 Reagents

6.2.1 *Mixed Acid Solution*

Prepared by mixing 150 ml of concentrated sulphuric acid with 150 ml of phosphoric acid and diluted to 1 litre with water.

6.2.2 *Standard Potassium Dichromate Solution* - 0.05 N.

6.2.3 *Standard Ferrous Ammonium Sulphate Solution* – 0.05 N.

6.2.4 *Indicator Solution* – Prepared by dissolving 0.2 g of barium diphenylamine sulphonate in 100 ml of water.

6.3 Procedure

6.3.1 Take about 5 g of conditioned test specimen and weigh it accurately. Extract the test specimen with 200 ml of water (*see* Note 1) at 50 ± 2°C for 2 hours with frequent stirring. Repeat the extraction once. Filter the extracts through a suitable filter paper (*see* Note 2). Wash the filter paper with water. Collect the two extracts and the washings into a beaker. Add 10 ml of mixed acid solution followed by 5 ml of ferrous ammonium sulphate solution. Add 1 ml of indicator solution and titrate against standard potassium dichromate solution until the first permanent blue colour appears.

NOTES

1 The material to liquor ratio should be 1.40

2 Whatman filter paper No.42 or its equivalent is suitable for this test.

6.3.2 Carry out blank determination using distilled water and the same quantities of reagents.

6.3.3 Calculate the percentage of water soluble chromium (as sodium chromate) by the following formula:

$$P = \frac{(A-B)\times 0{\cdot}27}{W}$$

where

P = percentage by weight of water soluble chromium (as sodium chromate),

A = volume in millilitres of potassium dichromate required for the blank (*see* **6.3.2**),

B = volume in millilitres of potassium dichromate required for the test (*see* **6.3.1**), and

W = weight in grams of the conditioned test specimen.

6.3.4 Repeat the test given in **6.3.1** and calculate separately the percentage of water soluble chromium (as sodium chromate) in each test specimen.

6.3.5 Calculate the average of the values obtained as in **6.3.3** and **6.3.4**.

6.4 Report the value obtained as in **6.3.5** as the percentage of water soluble chromium (as sodium chromate) present in textile materials.

7 SECOND METHOD

7.1 Apparatus

7.1.1 *Conical Flask*

7.1.2 *Nessler Tubes*

7.2 Reagents

7.2.1 *Dilute Sulphuric Acid Solution* – 10 percent (*w/v*).

7.2.2 *Buffer Solution*– prepared by dissolving 9.90g of boric acid and 3.81g of sodium borate in sufficient amount of water and made up to one litre with distilled water.

NOTE — The buffer solution should be of *p*H 7.8.

7.2.3 *Diphenyl Carbazide Solution* – 0.2 percent solution (*w/v*) prepared by dissolving diphenyl carbazide [CO (C_6H_5NH-NH)$_2$] in 9:1 mixture of rectified spirit and glacial acidic acid (*v/v*).

7.2.4 *Standard Potassium Dichromate Solution* prepared by dissolving 0.01 g of potassium dichromate per litre.

7.3 Procedure

7.3.1 From the conditioned test sample, weigh exactly 2.5 g of test specimen. Cut it into small pieces and transfer them to the conical flask. Add 50 ml of buffer solution. Weigh the conical flask and note the weight. Maintain the contents of the conical flask at 50 ± 2°C for 30 minutes with occasional shaking. Cool the flask to room temperature. Replace the loss in weight by addition of water. Filter the solution and collect the filtrate.

NOTE — If the extract is coloured, the colour should be destroyed by adding 2 ml of liquid bromine to the extract and then boiling the solution vigorously to evaporate off the bromine.

7.3.2 Take 20 ml of filtrate in a Nessler tube. Add to it 5 ml of dilute sulphuric acid and 2 ml diphenyl carbazide solution and make up the volume to 100 ml. Keep the contents in the flask for 10 minutes. Compare the colour developed with that of the solutions in which known quantities of potassium dichromate solution are taken separately instead of 20 ml of filtrate and treated similarly.

NOTE — A violet pink colour is developed with diphenyl carbazide.

7.3.3 Calculate the percentage of water soluble chromium (as potassium dichromate) by the following formula:

$$P = 0.001 \times v$$

where

P = percentage by weight of water soluble chromium (as potassium dichromate), and

v = volume in millilitres of standard potassium dichromate solution required to produce colour equal to colour of the extract.

7.3.4 Repeat the test with the remaining test specimens and calculate the percentage of the soluble chromium in each test specimen.

7.3.5 Calculate the average of the values obtained as in **7.3.3** and **7.3.4**.

8 REPORT

The report shall include the following information:

a) Type of material tested;
b) Method followed;
c) Chromium, percent (as sodium chromate); or
d) Chromium, percent (as potassium dichromate).

DETERMINATION OF WATER SOLUBLE MATTER OF TEXTILE MATERIALS

(*Source* : IS 3456 : 1966)

In textile industry textile materials undergo various treatments, in the course of which extraneous matter of various types, such as sizing or finishing material, water soluble matter is gathered by or added to the original textile material. An Indian Standard for determining size or finish, ash and fatty matter in cotton textile materials has already been published. The water soluble matter if present beyond certain limits in the textile materials adversely affects its quality.

1 SCOPE

It prescribes a method for determination of water soluble matter of textile materials.

2 SAMPLING

2.1 Sampling for Fibre and Yarn

2.1.1 *Lot* (*Fibre or Yarn*) – The quantity of fibre or yarn from the same source shall constitute a lot. If the lot contains more than 200 kg of fibre or yarn, it shall be divided in sub-lots each weighing 200 kg or less.

2.1.2 From a sub-lot 15 increments each approximately weighing 10 g shall be taken from different parts so that a representative sample is obtained. All the increments thus collected shall be thoroughly mixed. This shall constitute the test sample.

2.2 Sampling for Fabrics

2.2.1 *Lot* (*Fabric*) – The quantity of fabrics manufactured under relatively uniform conditions shall constitute a lot.

2.2.2 The number of pieces to be selected from a lot shall be in accordance with Table 1. The pieces thus selected shall constitute the gross sample.

Table 1 Sample Size

Lot Size (1)	Sample Size (2)
UP to 100	3
101 " 300	4
301 " 500	5
501 and above	7

2.2.3 From each piece in the gross sample about 25 g of fabric shall be taken out from at least two different parts. The parts shall then be cut into further smaller pieces and thoroughly mixed. The pieces thus collected shall constitute the test sample.

3 TEST SPECIMENS

From the test sample, take out at least two test specimens each weighing about 10 g.

NOTE — If the sample under analysis is loose fibre, take about 5 g of the test specimen.

4 CONDITIONING OF TEST SPECIMENS

Prior to test, the test specimens shall be conditioned for 24 hours to moisture equilibrium in a standard atmosphere at 65 ± 2 percent relative humidity and 27 ± 2°C temperature. However, in case of fabrics which weigh more than 270 g/m^2, the test specimens shall be conditioned for 48 hours.

5 APPARATUS

5.1 Flat-Bottom Flasks – of suitable capacity with a glass stopper incorporating a stop-cock.

NOTE — The flasks that are used for the preparation of the extract should not be used for any other purpose.

5.2 Water Cooled Condensers

6 REAGENT

6.1 Distilled Water

7 PROCEDURE

7.1 Condition the test specimens to moisture equilibrium in the standard atmosphere (*see* **4**) and weigh acurately each test specimen.

7.2 Put a test specimen in the flask and add sufficient amount of water to it to make a liquor to material ratio of 20:1 (*see* Note 1). Connect the flask to the condenser and bring rapidly to the boil and continue to boil the liquor gently for 60 minutes. Disconnect and remove the flask while the liquor is still boiling and close it immediately with the glass stopper fitted with stop-cock.

Rapidly cool the flask to room temperature (27 ± 2°C). Do not remove or open the tap until ready for filtration. Reject any extract where the flask is not under vacuum at the time of opening. Filter the extract and wash the residue with small amount of water. Take the filtrate and washings in a tared vessel and evaporate the extract to dryness (*see* Note 2). Dry the residue to constant weight at 105 to 110°C.

NOTES

1 If the test specimen is wool, the liquor to material ratio should be 50 1

2 The filtrate and washings may be diluted to a suitable volume and a measured amount of the solution may be evaporated for estimation.

8 CALCULATIONS

8.1 Calculate the water soluble matter as a percentage of the conditioned weight of the specimen by the following formula:

$$P = \frac{W_2}{W_1} \times 100$$

where

P = percentage of water soluble matter;

W_2 = weight, in g, of the residue (*see* **7.2**); and

W_1 = Weight, in g, of the conditioned test specimen (*see* **7.1**).

8.2 Repeat the test as given in **7.2** with the remaining test specimen(s) and calculate the percentage of water soluble matter in each test specimen.

8.3 Calculate the average of the values obtained as in **8.1** and **8.2** and report it as the percentage of water soluble matter of the textiles.

9 REPORT

Calculate the average of the values obtained as in **8.1** and **8.2**, and report it as the percentage of water soluble matter of the textiles.

ESTIMATION OF BENZENE-METHYL ALCOHOL SOLUBLE MATTER IN TEXTILE MATERIALS

(*Source* : **IS 5152 : 1969**)

In material specifications on woollen textile materials like felts, the requirement of benzene-methyl alcohol-soluble matter is normally prescribed. Extraction of textile materials with such solvents would indicate the amount of oil and fatty matter present in textile materials.

1 SCOPE

It prescribes a method for determination of benzene-methyl alcohol-soluble matter in textile materials.

2 PRINCIPLE

A known amount of test sample is extracted with benzene -methyl alcohol mixture. The solvent is dried and the residue is expressed as the percentage of the weight of the conditioned textile material.

3 SAMPLING

3.1 Sampling of Yarn

3.1.1 *Lot*

The quantity of yarn from the same source shall constitute a lot. If the lot contains more than 200 kg of yarn, it shall be divided in sub-lots, each weighing 200 kg or less.

3.1.2 From the sub-lot 15 increments each approximately weighing 10 g shall be taken from different parts so that a representative sample is obtained. All the increments, thus, collected shall be thoroughly mixed to get a test sample.

3.2 Sampling of Fabrics

3.2.1 *Lot*

The quantity of fabric manufactured under relatively uniform conditions shall constitute a lot.

3.2.2 The number of pieces to be selected from a lot shall be as given below. The pieces selected shall constitute the gross sample:

Lot Size	*Sample Size*
Up to 100	3
101 " 300	4
301 " 500	5
501 and above	7

3.2.3 From each piece in the gross sample about 25 g of fabric shall be taken out from at least two different parts. The parts shall be then cut into further smaller pieces and thoroughly mixed. The pieces, thus, collected shall constitute a test sample.

4 PREPARATION OF TEST SPECIMENS

Cut the test sample into small pieces. Mix all the pieces thoroughly. Draw at least three test specimens from among these pieces such that each specimen weighs about 5 g.

5 CONDITIONING OF TEST SPECIMENS

Prior to test, the test specimens shall be conditioned for 24 hours to moisture equilibrium in a standard atmosphere at 65 ± 2 percent relative humidity and 27 ± 2°C temperature [*see also* IS 196:1966 'Atmospheric conditions for testing' (*revised*)].

6 APPARATUS

6.1 Soxhlet Apparatus

7 REAGENTS

7.1 Benzene-Methyl Alcohol Mixture – Prepared by mixing three volumes of benzene (*see* IS 1840:1961 'Benzene, reagent grade') with two volumes of methyl alcohol [*see* IS 517:1986 'Methanol methyl alcohol) (*second revision*)'].

8 PROCEDURE

8.1 Condition the test specimens to moisture equilibrium in standard atmosphere (*see* **5**). Weigh each test specimen accurately.

8.2 Take a test specimen and put it in thimble (*see* Note). Extract the specimen with 150 ml of benzene-methyl alcohol mixture in a soxhlet apparatus for 3 hours siphoning the solvent at a minimum rate of 10 extractions per hour.

NOTE — If the thimble is not available, the test specimen should be wrapped in filter paper

8.3 Evaporate the extract in a tared flask. Dry the residue to constant weight at 105 to 110°C and weigh.

8.4 Calculations

8.4.1 Calculate the percentage of benzene-methyl alcohol-soluble matter present in the textiles by the following formula:

$$p = \frac{b}{a} \times 100$$

where

p = percent, by weight, benzene-methyl alcohol-soluble matter in the test specimens;

b = weight, in g, of the residue (*see* **8.3**); and

a = conditioned weight, in g, of the test specimen (*see* **8.1**).

8.5 Repeat the test with the remaining test specimens and calculate the benzene-methyl alcohol-soluble matter in each test specimen.

8.6 Calculate the average of the values obtained as in **8.4.1** and **8.5**.

9 REPORT

Report the value obtained as in **8.6** as the benzene-methyl alcohol-soluble matter present in the test sample.

METHOD FOR DETERMINATION OF ETHER SOLUBLE MATTER IN TEXTILE MATERIALS

(*Source* : IS 4390 : 1967)

In the cotton textile industry, yarn or fabric undergoes treatments in the course of which extraneous matter of various types is gathered by or added to the original material. The ether-soluble matter, if present beyond certain limits in the textile goods used as insulating materials in electrical industry, affects the quality of the insulating materials.

1 SCOPE

It prescribes a method for determination of ether-soluble matter in textile materials.

2 SAMPLING

2.1 Sampling for Fibre and Yarn

2.1.1 *Lot (Fibre or Yarn)*

The quantity of fibre or yarn from the same source shall constitute a lot. If the lot contains more than 200 kg of fibre of yarn, it shall be divided in sub-lots each weighing 200 kg or less.

2.1.2 From a sub-lot, 15 increments each approximately weighing 10 g shall be taken from different parts so that a representative sample is obtained. All the increments thus collected shall be thoroughly mixed. This shall constitute the *test sample.*

2.2 Sampling for Fabrics

2.2.1 *Lot (Fabric)*

The quantity of fabrics manufactured essentially under uniform conditions shall constitute a lot.

2.2.2 The number of pieces to be selected from a lot shall be as given below. The pieces thus selected shall constitute the gross sample.

Lot Size	*Sample Size*
Up to 100	3
101 " 300	4
301 " 500	5
501 and above	7

2.2.3 From each piece in the gross sample above 25 g of fabric shall be taken out from at least two different parts. The parts shall then be cut into further smaller pieces and thoroughly mixed. The pieces thus collected shall constitute the *test sample.*

3 TEST SPECIMENS

From the test sample, cut at least two test specimens each weighing about 10 g. Cut the test specimens into small pieces.

4 CONDITIONING OF TEST SPECIMENS

Prior to test, the test specimens shall be conditioned for 24 hours for moisture equilibrium in standard atmosphere at 65 ± 2 percent relative humidity and 27 ± 2°C temperature.

5 APPARATUS

5.1 Soxhlet Apparatus

5.2 Reflux Condenser

6 REAGENTS

6.1 Quality of Reagents – Unless specified otherwise, pure chemicals shall be employed for tests and distilled water shall be used where the use of water or distilled water as reagent is intended.

NOTE — 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the test results

6.2 Ethyl Ether -- redistilled.

7 PROCEDURE

7.1 Take one test specimen conditioned as in **4.1** and weigh it accurately. Place it in a thimble of Soxhlet apparatus. Extract the test specimen with ethyl ether for 3 hours at a minimum rate of 6 c/h.

7.2 Reduce the extract, if necessary, by subsequent distillation to a volume of approximately 25 ml. Filter the extract through a rapid filter paper and collect the extract in a 50-ml tared flask. Wash the filter paper and the extraction flask with small portions of ether and add the washings to the extract.

7.3 Distill the extract to remove the solvent by heating the flask on a steam-bath. Dry the residue at 60 to 70°C to constant weight.

8 CALCULATION

8.1 Calculate the amount of ether-soluble matter by the following formula:

$$S = \frac{W}{a} \times 100$$

where

S = percentage, by weight, of ether-soluble matter;

W_1 = Weight, in grams, of the residue (ether-soluble matter) (*see* **7.3**); and

W_2 = Weight, in grams, of the conditioned test specimen (*see* **7.1**).

8.2 Repeat the test with the remaining test specimen(s) and calculate the percentage of ether-soluble matter in each test specimen.

8.3 Calculate the average of the values obtained as in **8.1** and **8.2**.

9 REPORT

9.1 Report the value obtained as in **8.3** as the ether-soluble matter in textile materials.

DETERMINATION OF IRON AND CHROMIUM IN TEXTILES

(*Source* : IS 4655 : 1968)

Iron and chromium are present in large quantities in textiles. dyed in mineral khaki. Mineral khaki dyed material is used by Defence Personnels and civilians as well for making uniforms. The iron and chromium content of the fabric would give an indication regarding the amount of mineral khaki present in the textile material. This standard would be useful for the purpose of determining iron and chromium present in the textile material.

1 SCOPE

It prescribes method for determination of iron and chromium present in textile materials, especially dyed in mineral khaki and olive green shades.

2 PRINCIPLE

A known amount of test sample is ashed and the amount of iron and chromium is determined as their oxides (Fe_2O_3 and Cr_2O_3) and expressed as the percentage of the conditioned weight of the test sample.

3 SAMPLING

3.1 Sampling for Yarn

3.1.1 *Lot* (*Yarn*)

The quantity of yarn from the same source shall constitute the lot. If the lot contains more than 200 kg of yarn, it shall be divided into sub-lots, each weighing 200 kg or less.

3.1.2 *Test Sample*

Unless otherwise agreed to between the buyer and the seller, 15 increments each approximately weighing 10 g shall be taken from different parts of each sub-lot so that a representative test sample is obtained. All the increments thus collected shall be thoroughly mixed.

3.2 Sampling for Fabrics

3.2.1 *Lot* (*Fabric*)

The quantity of fabrics manufactured essentially under uniform conditions shall constitute a lot.

3.2.2 *Gross Sample*

Unless otherwise agreed to between the buyer and the seller, the number of pieces to be selected from a lot to constitute gross sample shall be as given below:

Lot Size	*Sample Size*
Up to 100	3
101 " 300	4
301 " 500	5
501 and above	7

3.2.3 *Test Sample*

From each piece in the gross sample about 25 g of fabric shall be taken out from at least two different parts to constitute test sample. The parts shall then be cut into further smaller pieces and thoroughly mixed.

4 PREPARATION OF TEST SPECIMEN

Cut the test sample into small pieces. Mix all the pieces thoroughly. Draw at least 3 test specimens from among these pieces such that each specimen weighs 5 g.

5 CONDITIONING OF TEST SPECIMEN

Prior to test, the test specimen shall be conditioned for 24 hours to moisture equilibrium in a standard atmosphere at 65 ± 2 percent RH and 27 ± 2°C temperature.

6 APPARATUS

6.1 Porcelain Crucible

6.2 Beakers

7 REAGENTS

7.1 Quality of Reagents

Unless specified otherwise, pure chemicals shall be employed in tests and distilled water shall be used where the use of water or distilled water as reagent is intended.

NOTE — 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the test results.

7.2 Hydrogen Peroxide

6 percent (*w/w*) (or 20 volumes).

7.3 Sodium Hydroxide Solution – 20 percent (*w/v*).

7.4 Dilute Hydrochloric Acid – equal volumes of concentrated hydrochloric acids and water.

7.5 Dilute Sulphuric Acid – 10 percent (*w/v*).

7.6 Mixed Acid Solution – prepared by mixing 150 ml of concentrated sulphuric acid and 150 ml of phosphoric acid and made up to 1 litre with water.

7.7 Ferrous Ammonium Sulphate Solution – N/10.

7.8 Potassium Dichromate Solution – (a) N/10, and (b) N/20.

7.9 Stannous Chloride Solution – 5 percent (*w/v*).

7.10 Mercuric Chloride Solution – saturated.

7.11 Indicator Solution – prepared by dissolving 0.2 g of barium diphenylamine sulphonate in 100 ml of water.

7.12 Potassium Permanganate Solution – (a) saturated, and (b) N/20.

7.13 Potassium Bisulphate – anhydrous.

7.14 Potassium Iodide – crystals.

7.15 Starch Indicator – 1 percent solution.

7.16 Sodium Thiosulphate Solution – N/20.

7.17 Reinhardt Solution – prepared by dissolving 200 g of manganese sulphate in 1 000 ml of water to which is added a cooled mixture of 400 ml of concentrated sulphuric acid, 1 200 ml of water and 400 ml of syrupy phosphoric acid.

8 PROCEDURE

8.1 Condition the test specimens to moisture equilibrium in standard atmosphere (*see* **5**) and weigh each test specimen accurately.

8.2 Put a test specimen in porcelain crucible (*see* Note), ash it in a muffle furnace at 800°C for 15 minutes and fuse the ash over a bunsen flame to clear melt with 10 g of potassium bisulphate. Dissolve the melt in 100 ml of hot water and add 100 ml of hydrogen peroxide. Add enough amount of sodium hydroxide solution till the solution is slightly alkaline. Boil the solution gently for 5 minutes and filter it through Whatman No. 54 or its equivalent filter paper. Wash the precipitate with hot water. Collect the filtrate and the washings.

NOTE — If the amount of iron and chromium compounds which have been fixed properly on the fabric is to be determined the water-soluble compounds of iron and chromium (which have not been properly fixed) should be removed by the following procedure:

'Before ashing, put the test specimen in a 250 ml beaker. Add 100 ml of distilled water and boil it for 15 minutes. Wash the test specimen thoroughly, first with warm water and then with cold water. Dry the test specimen and follow the procedure given in 8.2'.

8.3 Dissolve the precipitate obtained as in **8.2** in 10 ml of hot dilute hydrochloric acid. Wash the filter paper thoroughly with distilled water till the washings are free from iron. Add 5 ml of hydrogen peroxide solution and reprecipitate iron with sodium hydroxide solution as in **8.2**. Boil it for 5 minutes. Filter off the precipitate and wash it till free from chromium.

8.4 Combine the filtrate as obtained in **8.2** and **8.3**.

8.5 Determination of Chromium

8.5.1 *First Method*

8.5.1.1 Concentrate the filtrate obtained as in **8.4** and neutralize it with dilute sulphuric acid. Add 10 ml of dilute sulphuric acid in excess. Add 25 ml of N/10 ferrous ammonium sulphate solution followed by 20 ml of mixed acid solution and 1 ml of indicator solution. Titrate the mixture against N/10 potassium dichromate solution to the first permanent blue colour.

8.5.1.2 Carry out a blank test by following the procedure given in **8.5.1.1** using distilled water instead of the filtrate obtained as in **8.4**.

8.5.1.3 Calculate the percentage of chromium as chromium oxide (Cr_2O_3) by the following formula:

$$A = \frac{(V_2 - V_1) \times 0{\cdot}253\,4}{W}$$

where

A = percent by weight of chromium as Cr_2O_3,

V_2 = volume in ml of N/10 potassium dichromate required for blank (*see* **8.5.1.2**),

V_1 = volume in ml of potassium dichromate required for the test (*see* **8.5.1.1**), and

W = weight in g of the conditioned test specimen (*see* **8.1**).

8.5.2 *Second Method*

8.5.2.1 Take the filtrate obtained as in **8.4** and make up the volume to 250 ml. Take 50 ml of the diluted solution in a flask and neutralize it with dilute sulphuric acid and add 10 ml of dilute sulphuric acid in excess. Cool the solution to room temperature. Add 2 g of potassium iodide crystals and keep the flask stoppered for 5 mintues in dark place. Titrate the liberated iodine against standard sodium thiosulphate solution using starch as an indicator.

8.5.2.2 Calculate the percentage of chromium as its oxide (Cr_2O_3) by the following formula:

$$P = \frac{A \times B \times 25 \cdot 34}{2W}$$

where

P = percent by weight of chromium as Cr_2O_3,

A = volume in ml of sodium thiosulphate solution required for the test,

B = strength of the sodium thiosulphate used, and

W = conditioned weight in g of the specimen (*see* **8.1**).

8.6 Determination of Iron

8.6.1 Dissolve the precipitate obtained as in **8.3** in hot dilute hydrochloric acid. Boil the solution and add stannous chloride solution drop-wise while boiling until the solution become colourless. Cool the solution to room temperature. Add 5 ml of mercuric chloride solution (*see* Note).

NOTE — Excess of stannous chloride should not be added as it would require more of mercuric chloride resulting in the precipitation of mercurous chloride which would interfere in the titration.

8.6.2 *First Method*

8.6.2.1 Add 20 ml of mixed acid solution to the solution obtained as in **8.6.1**. Add 1 ml of indicator and titrate against N/20 potassium dichromate solution to the first permanent blue colour.

8.6.2.2 Calculate the percentage of iron as its oxide (Fe_2O_3) by the following formula:

$$B = \frac{V_1 \times 0 \cdot 399\,2}{W}$$

where

B = percent by weight of iron as Fe_2O_3,

V_3 = volume in ml of N/20 potasium dichromate solution required for the test (**8.6.2.1**), and

W = weight in g of the conditioned test specimen (*see* **8.1**).

8.6.3 *Second Method*

8.6.3.1 Transfer the solution obtained as in **8.6.1** (after 5 to 10 minutes) to a large porcelain dish. Add to this 25 ml or Reinhardt solution and 400 ml of water. Rinse with a moderate amount of water and titrate against N/20 potassium permanganate solution with a constant stirring to a definite pink tint.

8.6.3.2 Carry out a blank titration on the reagents.

8.6.3.3 Calculate the percentage of iron as its oxide (Fe_2O_3) by the following formula:

$$B = \frac{(V_5 - V_4) \times 0 \cdot 399\,2}{W}$$

where

B = percent by weight of iron as Fe_2O_3,

V_5 = volume in ml of N/20 potassium permanganate (required for the test),

V_4 = volume in ml of N/20 potassium permanganate (required for blank), and

W = weight in g of the conditioned test specimen.

8.7 Repeat the procedure with the remaining test specimens.

9 REPORT

Report individually the values obtained as in **8.5.1.3** or **8.5.2.2** and **8.7**, as the percentage of chromium as its oxide (Cr_2O_3) and the values obtained as in **8.6.2.2** or **8.6.3.3** and **8.7** as percentage of iron as its oxide (Fe_2O_3) in the test specimens.

ESTIMATION OF RESIDUAL STARCH IN COTTON FABRICS AFTER DESIZING

(*Source* : IS 1967 : 1961)

Starch is applied to warp yarn during the sizing operation, prior to weaving. In order to obtain efficient results in bleaching, dyeing, printing and other finishing treatments, it is essential that starch and other ingredients of size present in grey cloth and also the natural non-cellulosic impurities in cotton are removed completely. Such a removal is accomplished in the processes of desizing and scouring. Desizing is done by steeping the cloth either in water or in dilute mineral acid or more advantageously, by treatment with amylolytic enzymes. Efficient desizing would remove more than 90 percent of the starch present. Starch, if not removed to this extent, will interfere with the efficiency of kiering, yielding degradation products with reducing properties; these products would act detrimentally especially on coloured yarns if they are present in the material under treatment. Hence a routine test to determine the quality of residual starch in the desized cloth is very necessary.

1 SCOPE

It prescribes a method for the estimation of residual starch in cotton fabrics.

2 SAMPLING

2.1 Sample to estimate the amount of residual starch in cotton material in a lot shall be selected so as to be representative of the lot.

2.2 Sample drawn in compliance with an agreement between the buyer and the seller to estimate the starch present in the material in the lot shall be held to be representative of the lot.

3 TEST SPECIMENS

3.1 From the sample under analysis (*see* **2.1** and **2.2**) draw a piece weighing about 10 g. Shred the piece into small bits and mix them thoroughly.

3.2 Draw, from the pieces so shredded, at least five test specimens each weighing about one gram.

4 DETERMINATION OF MOISTURE CONTENT, PERCENT

4.1 Take a test specimen (*see* **3.2**), determine its moisture content by the method prescribed in IS 199:1989 'Methods for estimation of moisture, total size or finish, ash and fatty matter in grey and finished cotton textile materials' given in section D/25.

4.2 Repeat the procedure on another test specimen (*see* **3.2**).

4.3 Calculate the average of the two values (*see* **4.1** and **4.2**).

5 PREPARATION OF THE EXTRACT

5.1 Take a test specimen (*see* **3.2**). Weigh it accurately. Boil it in about 150 ml of distilled water in a conical flask for about 45 minutes. Cool the contents in the flask and decant the supernatant liquid into a beaker.

NOTE — It would be advantageous to carry out the procedures prescribed in **4** and **5** simultaneously.

5.2 Add about 25 ml of distilled water to the residue in the conical flask and boil it for 30 minutes. Decant the supernatant liquid into the beaker.

5.3 Put a drop of iodine solution on the residue in the conical flask. Observe whether there is any appearance of blue colour.

5.4 Take the residue in the conical flask to be free from all starch if no blue colour is observed (*see* Note).

NOTE — If, however, blue colour is observed, repeat as many times as may be necessary the procedure prescribed in **5.2**.

5.5 Filter the decanted liquor twice through a G-3 size sintered glass curcible. Concentrate the filtrate by boiling, cool to room temperature and make up the volume to 100 ml.

6 ESTIMATION OF STARCH

6.1 Apparatus

6.1.1 *250-ml Conical Flasks* – two.

6.1.2 *Reflux Condenser*

6.2 Reagents

6.2.1 *Solution A, Potassium Dichromate Solution* – approximately 0.5 N, but not greater than 0.5 N, containing 24.5 g of potassium dichromate ($K_2Cr_2O_7$) and 300 ml of concentrated sulphuric acid per litre of the solution.

6.2.2 *Solution B, Ferrous Ammonium Sulphate Solution* – slightly greater than 0.1 N, but accurately standardized, containing 39.5 to 40 g of ferrous ammonium sulphate crystals [$FeSO_4(NH_4)_2SO_4 \cdot 6H_2O$] and 20 ml of concentrated sulphuric acid per litre of the solution.

6.2.3 *Phenyl Anthranilic Acid Indicator* – prepared by dissolving 0.13 g of anhydrous sodium carbonate in a small quantity of hot water, and dissolving in this solution 0.26 g, of phenyl anthranilic acid and making up the volume to 250 ml.

6.3 Procedure

Transfer 25 ml of the extract (*see* **5.5**) into a 250-ml flask. Add to this, 10 ml of solution A (*see* **6.2.1**) and 5 ml of concentrated sulphuric acid. Boil the mixture under reflux for one hour. Cool the contents, make up the volume to 100 ml. Titrate the solution against solution B (*see* **6.2.2**) adding 6 to 8 drops of the indicator towards the end of the titration (*see* Note).

NOTE — Appearance of characteristic green colour indicates the completion of the titration.

6.4 Carry out a blank simultaneously following the procedure prescribed in **6.3** but taking 25 ml of distilled water instead of the extract.

6.5 Calculate the oven-dry weight of the specimen by the formula given below:

$$\text{Oven-dry weight, in g,} = w - \frac{w \times m}{100}$$

where

w = weight, in g, of the specimen taken (*see* **5.1**); and

m = moisture content, percent, as calculated (*see* **4.3**).

6.6 Calculate the percentage of starch present in the specimen by the following formula:

$$\text{Percent of starch} = \frac{400 \times (v_1 - v_2) \times N \times 0.006\ 96}{W}$$

where

v_1 = volume, in ml, of solution B required for blank (*see* **6.4**);

v_2 = volume, in ml, of solution B required for the extract (*see* **6.3**);

N = normality of solution B; and

W = oven-dry weight, in g, of the specimen as calculated (*see* **6.5**).

NOTE — One millilitre of 1 N potassium dichromate corresponds to 0.006 96 g of starch

6.7 Repeat the procedure prescribed in **5** and **6** with the remaining specimens. Calculate the average of all the values.

7 REPORT

Report the average as obtained in **6.7** as the percentage of starch present in the sample.

ESTIMATION OF COMMON PRESERVATIVES

(*Source* : **IS 3522 (Part 1) : 1989, (Part 2) : 1983, (Part 3) : 1983)**

During storage or in use, most of the textile materials are liable to suffer damage as a result of attack by micro-organisms, fungi and bacteria. Numerous treatments have been developed for textile materials with different preservatives (fungicides and insecticides) to protect the material from staining and degradation arising from attack of micro organisms and insects.

Orthophenyl phenol (OPP) and tributyltin oxide (TBTO) is mainly used for protection of textiles in store and OPP is also used for temporary protection in outside use. Halogenated diphenyl urea derivatives (HDUD) is used for the working life protection of wool and other animal fibres and their blends from moth and beetle damage, during storage and use. Tar oil is used for jute fabrics, sacks, cordages, ropes and nets. Dichlorophen is used for cotton, flax, jute fabrics used as covers, convasses, tarpaulins, awnings, shop blinds, tentage, etc; either alone or incorporated in water and other proofing treatments. It is also used for pressed felts, woollen fabrics, carpet backings, ropes, cordages, slacks, sewing threads, hospital textiles, mattress covers, coated fabrics, mosquito nets, nettings and textiles for aeronautical application.

Most of the preservative agents have toxic properties in some measure and should be handled with care. Some of the chemicals used in the methods of test also present particular hazard. So the tests should only be carried out under the supervision of an experienced analyst.

The methods prescribed in this standard are applicable in estimating preservatives when present on the yarns and fabrics of different textile materials. Every precaution should be taken to protect the yarn or fabric,being sampled.

1 SCOPE

It prescribes methods for estimating the following preservatives on textiles:

a) Salicylanilide
b) Salicylic acid
c) Pentachlorophenol

d) Sodium silicoflouride
e) Zinc chloride
f) Zinc naphthenate

g) Copper napthenate
h) Copper-8 quinolin
j) Copper Salicylanilide
k) *p*-nitrophenol
m) 2, 4-dinitro-1-naphthol (DAN)
n) 4, 6-dinitro-ortho-cresol (DNOC)
p) Dichloro-diphenyl-trichloroethane (DDT)
q) Pentachlorophenyl laurate (PCPL)
r) Permethrin
s) Orthophenyl phenol (OPP)/2-phenyl phenol
t) Tributyltin oxide (TBTO)
u) Halogenated diphenyl urea derivatives (HDUD)
v) Tar oil
w) Dichlorophen

2 SAMPLING

2.1 Lot

The quantity of textile material of one definite type and quality delivered to a buyer against one despatch note shall constitute a lot.

2.2 Unless otherwise agreed to between the buyer and the seller, the number of bundles or pieces to be selected at random from a lot shall be in accordance with Table 1 or Table 2, respecitively.

Table 1 Sample Size for Yarn
(*Clauses* 2.2 *and* 2.3)

Lot Size (Number of Bundles in the Lot) (1)	Sample Size (Number of Bundles to be Selected) (2)
Up to 150	3
151 " 300	4
301 " 500	5
501 " 1 000	7
1 001 " 2 000	8
2 001 " 1 0000	9
10 001 and above	10

Table 2 Sample Size for Fabrics
(*Clauses* 2.2 *and* 2.3)

Lot Size (Number of Pieces in the Lot) (1)	Sample Size (Number of Pieces to be Selected) (2)
Up to 100	2
101 " 150	3
151 " 300	4
301 " 500	5
501 " 1 000	7

2.3 From each bundle of yarn or piece of fabric selected as in **2.2**, cut out small portions each weighing about 25 g from at least two different parts and mix them. This shall constitute the test sample. While taking the sample, care shall be taken to exclude a sufficient length of yarn or fabrics from both the ends

3 PREPARATION OF THE TEST SPECIMEN

3.1 Cut the test sample into small pieces. Mix all the pieces thoroughly and draw at least three test specimens from among these pieces each weighing about 1.5 g or as that required in the test.

4 QUALITY OF REAGENTS

Unless specified otherwise, pure chemicals shall be employed in tests and distilled water [*see* IS 1070 : 1992 'Reagent grade water' (*third revision*)] shall be used where the use of water as reagent is intended.

NOTE – 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the test results

5 CONDITIONING AND TESTING ATMOSPHERE

All the test specimens prior to test shall be conditioned to mositure equilibrium from the dry side in the standard atmosphere at 65 ± 2 percent relative humidity and 27 ± 2°C temperature, at least for 24 hours. All the mass determinations shall be made in the standard atmosphere after conditioning.

6 ESTIMATION OF SALICYLANILIDE

6.1 Principle

The salicylanilide is extracted from the textile by means of a dilute solution of disodium tetraborate and the extract is treated with a solution of 2, 6-dibromo-p-benzoquinonechlorimine. The blue indophenol colouring matter so formed is absorbed on a disc of Whatman No. 40 filter paper the shade of which is then compared, with the shades of a series of similar discs 'dyed' with the indophenol obtained from solutions containing different known amount of salicylanidide.

6.2 Reagents

6.2.1 *Disodium Tetraborate, 30 g/l Extraction Solution*

Prepared by dissolving 30 g of disodium tetraborate in about 900 ml of water. Add about 30 ml of cyclohexanol then make up to 1 000 ml with water. Shake the solution, remove excess of cyclohexanol by filtration through several layers of filter paper.

6.2.2 *Disodium Tetraborate, 5 g/l, Reagent, Wash Solution*

6.2.3 *2, 6-dibromo-p-benzoquinone Chlorimine 1 g/l Reagent Solution*

The solution is prepared by dissolving 0.1 g in 100 ml of 95 percent *v/v* ethanol. This solution is unstable; prepare it freshly within a few hours of use.

6.2.4 *Salicylanilide*

0.125 g/l, standard reference solution, prepared by gently heating 0 125 g of pure crystalized salicylanilide in 5 ml of water and 2 ml of 2 M sodium hydroxide solution. When the solid has been dissolved completely dilute to 1 000 ml with water.

6.3 Apparatus

6.3.1 *Paper Discs*, 20 mm diameter.

6.4 Procedure

6.4.1 Place three weighed portions of 0.50 g, 0.25 g, and 0.125 g respectively in separate, dry, flat-bottomed specimen tubes (75 mm × 20 mm) and add to each 5 ml of disodium tetraborate extraction solution. Allow a minimum period of 1/hour for the extraction, which is assisted by occasional gentle shaking or stirring. Extracts containing much suspended matter should be filtered or centrifuged before use but small amounts of suspended fibre are not determental, Prepare a series or working standard solutions of salicylanilide by suitable dilution of the reference solution with the disodium tetraborate extraction solution to cover the anticipated salicylanilide content of the material. A suitable range of prepared standared solution can be made as shown in Table 3.

Table 3 Standard Solution of Salicylanilide
(*Clause* 6.4.1)

Disc	Standard Reference Solution	Disodium Tetraborate Extraction Solution	Percentage Salicylanilide On Mass of Material Taken		
	ml	ml	0.5 g	0.25 g	0.125 g
1	10.0	15.0	0.05	0.10	0.20
2	9.0	16.0	0.045	0.09	0.18
3	8.0	17.0	0.04	0.08	0.16
4	7.0	18.0	0.035	0.07	0.14
5	6.0	19.0	0.03	0.06	0.12
6	5.0	20.0	0.025	0.05	0.10
7	4.0	21.0	0.02	0.04	0.08
8	3.0	22.0	0.015	0.03	0.06
9	2.0	23.0	0.01	0.02	0.04
10	1.0	24.0	0.005	0.01	0.02
11	0.5	24.5	0.0025	0.005	0.01

6.4.2 Place 1.0 ml of each extract and of each of the standard solutions in a separate dry specimen tube (100 mm × 25 mm) and mix with 0.2 ml of 2,6-dibromo-p-benzoquinone chlorimine reagent solution. Place immediately a filter paper disc in each tube and allow the whole to stand for 1 hour with occasional stirring, care being taken to keep each disc below the surface of the liquid. Remove the discs from the tubes, rinse them with the disodium tetraborate wash solution, place them on a white opal glass and cover them with separate microscopical cover slips. Estimate the salicylanilide content of the sample under test by comparing the colours of the disc(s) prepared from it with those prepared from the standard solutions. The percentage salicylanilide is that of the solution corresponding to the 'matching' disc.

NOTE — The comparison of the discs is facilitated by placing each on a separate small piece of white glazed tile.

6.4.3 Modification of the above procedure may sometimes be necessary. For example, if the material contains colouring matter extractable by the disodium tetraborate solution, it may be necessary to make a preliminary extraction of the salicylanilide with an organic solvent or to separate it from the colouring matter in some other way. Such modifications should, however be dictated by circumstances and are beyond the scope of this method.

7 ESTIMATION OF SALICYLIC ACID

7.1 Reagents

7.1.1 *Sodium Hydroxide Solution*, one percent (*m/v*).

7.1.2 *Phosphoric Acid Solution*, 5 percent (*m/v*).

7.1.3 *Petroleum Hydrocarbon Solvent*, boiling range 60 to 80°C (*see* IS 1745 : 1978 Petroleum hydrocarbon solvents (*second revision*)).

7.1.4 *Ether* [*see* IS 336:1973 'Ether (*second revision*)'].

7.1.5 *Standard Sodium Hydroxide Solution*, 0.1 N.

7.2 Procedure

7.2.1 Take a test specimen of about 5 g weighed accurately to the nearest mg. Boil it in 200 ml of one percent sodium hydroxide solution for one hour. Filter the solution and wash the residue with hot water till free from alkali. Concentrate the filtrate and the washings so collected to about 100 ml. Add phosphoric acid solution till the extract is just acidic. Extract the solution with equal volume of petroleum hydrocarbon solvent or a mixture of equal volumes of pertroleum hydrocarbon solvent and ether. Evaporate the solvent to get the residue of salicylic acid. Dissolve the residue in warm 15 ml of 95 percent alcohol (previously neutralized to phenol red solution). Add 20 ml of water to this solution and titrate it against 0.1 N sodium hydroxide solution using phenol red as indicator.

7.3 Calculation

7.3.1 Calculate the amount of salicylic acid in the test specimen by the following formula.

$$S = \frac{0{\cdot}013\,8 \times a \times 100}{M}$$

where

S = the amount of salicylic acid, in percent, by mass;

a = volume in ml, of 0.1 N sodium hydroxide solution; and

M = mass in g, of the test specimen.

NOTE — 1 ml of 0.1 N sodium hydroxide solution is equivalent to 0.013 8 g of salicylic acid.

7.4 Repeat the test with the remaining test specimens and calculate the amount of salicylic acid in each test specimen.

7.5 Calculate the average of the results obtained as in 7.3 and 7.4 and report it as the amount of salicylic acid in the test sample.

8 ESTIMATION OF PENTACHLOROPHENOL

8.1 Principle

The treated textile is steam distilled in the presence of hydrochloric acid and the pentachlorophenol in the distillate extracted with 1, 1, 1-trichloroethane and complexed with copper sulphate-pyridine reagent. The optical density of the complex in 1, 1, 1-trichloroethane is measured on a suitable spectrophotometer at 450 nm.

NOTES

1 Complete removal of pentachlorophenol from some forms of wool is not always possible.

2 The method is applicable to estimation of pentachlorophenol and also to the estimation of pentachlorophenol in the presence of pentachlorophenyllaurate.

8.2 Reagents

8.2.1 *1, 1, 1 - trichloroethane*

8.2.2 *Pyridine*

8.2.3 *Sodium Sulphate, Anhydrous*

8.2.4 *Copper Sulphate Reagent Solution*, 50 g/l

8.2.5 *Hydrochloric Acid Concentrated* 36 percent (*m/m*) (11 M)

8.2.6 *Pentachlorophenol Standard Reagent*, recrystallized, melting point 188°C, *Min*

8.3 Procedure

8.3.1 Weigh 2.5 ± 0.05 g of the material, cut into small pieces of not more than 5 mm square and place in a 250 ml round bottomed flask (B 24/29) socket. Add 60 ml of water followed by 20 ml hydrochloric acid and a few anti bumping granules. Fit the flask up for steam distillation and steam distil the contents of the flask ensuring that constant volume is maintained by applying gentle heat as necessary. Collect 300 ml of distillate in a suitable receiver, paying particular care to prevent loss of pentachlorophenol in the distillate by having adequate cooling. Discontinue the external heating of the flask a few minutes before disconnecting the steam supply. Disconnect the condenser and fit it vertically over the distillate receiver. Wash down the condenser with 25 ml to 30 ml of trichloroethane and collect the washings in the distillate. Transfer the distillate and trichloroethane washing to 500 ml seperating funnel and shake thoroughly. Allow the layers of water and trichloroethane to separate completely before running off the trichloroethane layer into a 100 ml separating funnel. Wash condenser and distillate receiver with a further 25 ml to 30 ml of trichloroethane and add this to the aqueous solution in the 500 ml seperating funnel.

8.3.2 Repeat the extraction as previously described and add the trichloroethane layer to the first trichloroethane extract in the 100 ml separating funnel. Add to the bulked trichloroethane extract 10 ml of copper sulphate-pyridine reagent (prepared by mixing 4 ml of pyridine with 8 ml of copper sulphate solution immediately before use), and shake well. After effecting complete separation of the aqueous and trichloroethane layers run the lower tricloroethane layer into 100 ml standard flask via a small funnel containing anhydrous sodium sulphate supported by means of a quartz wool plug. Add a small quantity of trichloroethane to the copper sulphate-pyridine solution remaining in the separating funnel, shake and allow the layers to separate before running the trichloroethane layer through the quartz wool filter and collect in the standard flask. Wash the filter with further small quantities of trichloroethane and finally make up to 100 ml with trichloroethane.

8.3.3 Determine the optical density of the solution using a suitable spectrophotometer at a wavelength of 456 nm using trichloroethane as a blank. Estimate the pentachlorophenol content by reference to a calibration graph prepared from known standards of pentachlorophenol.

8.4 *Calibration*

8.4.1 *Direct*

Prepare a calibration graph using 5, 10 and 15 ml aliquots of a standard solution of pentachlorophenol reagent in trichloroethane (1 g /200 ml) to cover a range of 1.0, 2.0 and 3.0 percent respectively. Dilute each aliquot to 50 ml to 60 ml with trichloroethane. Add 10 ml of copper sulphate-pyridine reagent and proceed as described in **8.3.1** to **8.3.3**.

Plot optical density against concentration of pentachlorophenol.

8.4.2 *Indirect*

Prepare a calibration graph using 5, 10 and 15 ml aliquots of a standard solution of pentachlorophenol reagent (1g/200 ml) in dilute sodium hydroxide (only sufficient hydroxide solution to ensure complete solution of the pentachlorophenol is necessary). Place each aliquot in a round bottomed flask, add 60 ml of water and 20 ml hydrochloric acid. Fit the flask for distillation and proceed as described in **8.3.1** to **8.3.3**.

If the distillation technique is satisfactory then the graph obtained by the procedure described under **8.4.1** and **8.4.2** should be the same.

9 ESTIMATION OF SODIUM SILICOFLUORIDE

9.1 Reagents

9.1.1 *Standard Sodium Hydroxide Solution*, 0.01 N.

9.1.2 *Calcium Chloride Solution*, 4 N.

9.2 Procedure

9.2.1 Take a test specimen of about 5 g and weighed accurately to the nearest mg.

9.2.2 Extract the specimen with hot water at 80 to 90°C for 30 minutes keeping the material to liquor ratio as 1 : 30. Cool the solution and add 20 ml of calcium chloride solution. Titrate the extract (without filtering) with 0.01 N standard sodium hydroxide using phenolphthalein as indicator.

9.3 Calculation

Calculate the amount of sodium silicofluoride in the test specimen by the following formula:

$$S = \frac{V \times 0{\cdot}000\,47 \times 100}{M}$$

where

S = amount of sodium silicofluoride, percent, by mass;

V = volume, in ml, of 0.01 N sodium hydroxide; and

M = mass in g, of the test specimen.

NOTE — One mm of 0.01 N sodium hydroxide = 0.000 47 g of sodium silicofluoride.

9.4 Repeat the test specimens and calculate the amount of sodium silicofluoride in each test specimen.

9.5 Calculate the average of the results obtained as in **9.3** and **9.4** and report it as the amount of sodium silicofluoride in the test sample.

10 ESTIMATION ON ZINC IN TEXTILES TREATED WITH ZINC CHLORIDE AND ZINC NAPHTHENATE

10.1 General

If this method is used, then jute and similar materials, which contain metal impurities forming oxinates at *p*H 5 to *p*H 6 will be determined as zinc and it is necessary, therefore, to carry out a blank determination on the unproofed material.

NOTE — where the estimation of zinc relates solely to assessing the content of zinc naphthenate, it is expected that the proofer or finisher will guarantee that the zinc is present solely as naphthenate and is not mixed with other zinc soaps or compounds.

10.2 Volumetric Method

The material is subjected to wet oxidation. The zinc is precipitated as zinc oxinate from a buffered solution, the precipitate dissolved in acid and the oxine content determined after bromination by an iodometric titration.

10.2.1 *Reagents*

10.2.1.1 *Sodium acetate solution, M*

10.2.1.2 *Acetic acid 1 M,* dilute 5 M reagent solution five times.

10.2.1.3 *Ammonia solution,* 5 M reagent solution

10.2.1.4 *Ammonium chloride,* 2 M reagent solution

10.2.1.5 *8-hydroxyquinolin 20 g/l reagent solution*

The solution is prepared by dissolving 2 g of 8-hydroxyquinolin in 100 ml of M acetic acid.

10.2.1.6 *Hydrochloric acid 2 M,* dilute 5 M reagent solution.

10.2.1.7 *Nitric acid,* concentrated 70 percent (*m/m*) (16 M)

10.2.1.8 *Sulphuric acid,* concentrated, 98 percent (*m/m*) (approximately 18 M).

10.2.1.9 *Potassium bromate,* 0.02 M standard volumetric solution

The solution is prepared by dissolving 2.784 g potassium bromate and 12.0 g potassium bromide in water and making up to 1 000 ml with water.

10.2.1.10 *Sodium thiosulphate*, 0.1 M standard volumetric solution

10.2.1.11 *Potassium iodide*, 0.5 M non-standardized volumetric solution

10.2.1.12 *Methyl red 0.05 g/l indicator solution*

The solution is prepared by dissolving 0.05 g of methyl red in 1 000 ml of a solution consisting of 800 ml 95 percent (*v/v*) ethanol and 200 ml of water.

10.2.1.13 *Soluble starch indicator solution*, 10 g/l

10.2.2 *Procedure*

Weigh accurately about 2 g of the material, transfer to a 200 ml Kjeldahl flask. Add 10 ml of sulphuric acid followed by gradual addition of nitric acid until there is no reaction on further addition of acid (this volume can vary and may be as much as 30 ml).

Apply heat gradually and digest with the further addition of nitric acid if necessary until organic matter is completely destroyed. Evaporate down to fuming, cool, add 5 ml to 10 ml of water and boil to remove nitric acid. Cool, dilute to approximately 50 ml with water and filter if necessary through a Whatman No. 42 filter paper.

10.2.3 To the solution add a few drops of methyl red, make just alkaline with ammonia solution, add 120 ml of ammonium chloride solution, 25 ml of sodium acetate solution, 6 ml of acetic acid and dilute the solution to approximately 200 ml with water. Adjust the *p*H value of the solution approximately to 5.3 by adding acetic acid or ammonia solution as appropriate using a *p*H meter. Heat the solution to 70°C, add 10 ml of 8-hydroxyquinolin reagent solution, bring to the boil and place on a heated steam bath for 30 minutes. Check that there is excess of reagent solution then filter through a suitable sintered glass crucible (for example G 3 or G 4) and wash the precipitate with hot water to remove excess 8-hydroxyquinolin that is until the washings are free from colour. Transfer the precipitate to a beaker, and extract the crucible with hot hydrochloric acid, then transfer the washings to the beaker, bulk up to approximately 100 ml with hydrochloric acid and boil solution to dissolve the precipitate. Transfer the solution to a 500 ml conical flask. Cool, add 1 ml of methyl red indicator solution and titrate with potassium bromate until the colour of the solution becomes sulphur yellow. Add a further 1 ml of indicator solution.

Continue the process until a 1 ml portion of the indicator is decolorized immediately. This second state of the titration should not take more than a few mm of the potassium bromate solution. Note the volume of titrant added. Allow the solution to stand for 2 minutes to ensure complete bromination of the 8-hydroxyquinolin, add 5 ml of the potassium iodide solution using soluble starch as indicator. The back titration should not exceed 2 ml. Carry out a reagent blank determination using the same amount of indicator solution as used in the determination.

1 ml of 0.2 M potasium bromate solution = 0.000 980 6 g zinc.

11 ESTIMATION OF COPPER IN TEXTILES TREATED WITH COPPER NAPHTHENATE

11.1 General

This method gives the quantity of organic copper as well as nepthanic acids derived from copper naphthenate. Use of inorganic copper such as copper sulphate is not recommended in preservative formulations and hence the extraction with benzene has been specified which will extract only organic copper as naphthenate from which both copper and naphthanic acid can be estimated. In absence of standard naphthenic acids, these may be estimated gravimetrically and copper by colorimetric method.

11.2 Reagents

11.2.1 *Benzene or Petroleum ether*, G.p - 40 – 60°C

11.2.2 *Hydrochloric acid* (approximately 6 N)

11.2.3 *Concentrated Nitric Acid*

11.2.4 *Ammonia Solution*, 5 M reagent solution

11.2.5 *Standard Copper Solution*, Prepared as follows:

Dissolve 0.983 g Analar grade copper sulphate ($CuSO_4.5H_2O$) in distilled water and make up to 500 ml in a volumetric flask.

1 ml of this solution = 0.5 mg copper (as Cu)

Standard coper solution may also be prepared from electrolytic copper.

11.3 Procedure

11.3.1 From the test sample cut out pieces each weighing about 10 g and condition them to moisture equilibrium in the standard atmosphere of 27 ± 2°C temperature and 65 ± 2 percent relative humidity. Saturated sodium nitrite solution may be used for such atmosphere.

11.3.2 From the test specimens weigh about 10 g of the conditioned material correct to the nearest mg and put in a thimble or properly wrap in a filter paper so that any solid matter detached from the fabric does not enter the extraction flask.

11.3.3 Extract the test specimen thoroughly for 3-4 hours with benzene or petroleum ether in a Soxhlet extraction apparatus at the rate of 8-10 extractions per hour.

11.3.4 Recover most of the solvent from the extraction flask and evaporate the remaining solvent by heating the extraction flask at 105 ± 3°C in an oven for 20-30 minutes. A control experiment is run simultaneously for estimation of solvent, extracts other than copper naphthenate. Add 100 ml of hydrochloric acid (6 N) and reflux for 30 min when naphthenic acids (brown colour) will separate out and copper will go into acidic aqueous phase as copper salt. Cool the flask and quantitatively transfer the material to a separating funel. Extract with solvent ether three times (50 ml, 30 ml), combine the ether extracts and wash with distilled water till the wash water is free from acid. Acidic aqueous layer is released from estimation of copper.

11.3.5 *Estimation of Naphtenic Acids*

11.3.5.1 Take the combined ether extracts in a tared flask and remove the solvent. Add 1-2 ml acetone and heat at 105 ± 3°C for 30 minutes. Weigh the flask containing brown viscous mass of naphthenic acids. Subtract the extractible matter obtained in blank. Estimate the percentage of naphthenic acids by the formula:

$$\text{Naphthenic acids, percent} = \frac{m_2 - m_1}{m}$$

where

m_1 = mass of empty flask,

m_2 = mass of flask plus material minus extractibles obtained in the blank; and

m = mass of the specimen taken.

NOTE - The acid value of the material may be checked by dissolving it in neutral in alcohol and titrating with 0 1 N KOH (with phenolphthalein as indicator The acid value is found to be 178)

11.3.6 *Estimation of copper*

11.3.6.1 Take the acidic aqueous extract in a beaker (250 ml), add 2-3 ml concentrated nitric acid and carefully heat to reduce the volume to 10-15 ml. Cool, dilute with water (filter, if necessary), add excess ammonia to develop blue colour and make up the volume to 50 ml.

Take 10, 20, 30 and 40 ml of standard copper solutions in separate 50-ml volumetric flasks, develop blue colour by adding excess ammonia and make up the volume of each to 50 ml. Transfer each solution to colorimer tube and take their colorimeter readings against blank set at zero. Prepare a standard curve (colorimeter reading *Vs* copper concentration). Calculate the amount of copper in the experimental solution from its colorimeter reading and the standard curve. In absence of colorimeter the colour of the solution can be matched against that of standard copper solution in Nessler tubes.

12 ESTIMATION OF COPPER 8-HYDROXYQUINOLIN

12.1 General

The method is applicable to the determination of copper 8-hydroxyquinolin in textile materials provided that dyestuffs which are soluble in sulphuric acid or dichloromethane are absent. The copper 8-hydroxyquinolin is extracted from the material by hot extraction with sulphuric acid. The acid solution after neutralizing is extracted with dichloromethane and the optical density of dichloremethane solution is measured on a suitable spectrophotometer at 410 nm.

12.2 Reagents

12.2.1 *Dichloromethane*

12.2.2 *Sodium Sulphate Anhydrous*

12.2.3 *Ammonia Solution,* 5 M

12.2.4 *Sulphuric Acid,* 2.5 M

12.2.5 *Copper 8-hydroxyquinolin*

Standard reference reagent, prepared by adding excess of a solution of copper sulphate (60 g/1) to 100 ml solution of 8-hydroxyquinolin (650 g/1) in 95 percent (*v/v*) ethanol. Filter off the precipitated copper 8-hydroxyquinolin on a suitable sintered glass filter, wash with water to remove excess copper sulphate. Air dry at 90°C for 1 hour. The reagent should be bright yellow in colour.

12.2.6 *Copper 8-hydroxyquinolin*

Standard reference solution, prepared by dissolving 1.000 g standard reference reagent in 1 000 ml of dichloromethane.

12.2.7 *Bromocresol Green Indicator Solution*

0.4 g/l. Warm 0.1 g of bromocresol green with 2.9 ml of 0.05 M sodium hydroxide solution and 5 ml of 95 percent (*v/v*) ethanol; after solution is effected, add 50 ml of 90 percent (*v/v*) ethanol and dilute to 250 ml with water.

12.3 Procedure

Digest on a boiling water bath for 15 minutes 1.0 g of the finely divided material in a 100 ml beaker with 25 ml of sulphuric acid (with dense fabrics it can be advantageous to place the sample and acid in a suitable high speed disintegrator or homogenizer, then transfer the pulp suspension to the beaker). Filter the extract through a quartz plug into a 400 ml beaker. Repeat the extraction three times with 25 ml quantites of sulphuric acid filtering each extract through the original quartz wool plug. Cool the bulk solution, add bromocresol green indicator and adjust to *p*H 6 ± 1 with ammonia solution added from a burette, cooling the solution from time to time as necessary (The *p*H adjustment can be done advantageously by the use of a *p*H meter). Transfer the solution to a 500 ml separating funnel and add 20 ml of dichloromethane. Shake the funnel for at least 1 min. Allow the contents to separate out, run off the dichloromethane layer through anhydrous sodium sulphate supported on a quartz wool plug directly into a 100 ml graduated flask. Repeat the dichloromethane extraction four times with further 10 ml volumes of dichloromethane, filtering each through the same sodium sulphate plug filter. Bulk the dichloromethane extracts to 100 ml and measure the optical density of the solution on a suitable spectrophotometer at a wavelength of 410 nm using 5 mm cells with dichloromethane as a blank. The calculation of copper 8-hydroxyquinolin may be made from a previously prepared calibration graph.

Calculate the copper content as follows:

Percentage copper content = percentage of copper 8-hydroxyquinolin × 0.180 6.

12.4 Calibration

Take 0.0, 5.0, 7.5 and 10.0 ml of the standard reference reagent equivalent to 0.0, 0.5, 0.75 and 1.0 percent respectively. Place in 100 ml flask and dilute each to 100 ml with dichloromethane. Determine the optical density of the solution in 5 mm cells at a wavelength of 410 nm using dichloromethane as a blank. Prepare graph of optical density against percentage of 8-hydroxyquinolin.

13 ESTIMATION OF COPPER SALICYLANILIDE

13.1 Estimation of Copper Content

13.1.1 Take a test specimen of about 10 g weighed accurately. Transfer the test specimen to a 90 ml porcelain crucible. Place the crucible in a muffle furnace and slowly increase the temperature to about 300°C. After the sample is charred remove the crucible from the furnace.

13.1.2 Cool the crucible and moisten the carbonaceous skeleton with 1 ml sulphuric acid. Heat the contents until white fumes cease to volatilize and grey ash remains in the crucible. Digest the residue with 20 ml of distilled water and 5 ml of sulphuric acid by heating nearly to boil for about 5 minutes. Cool the solution and neutralize it with ammonium hydroxide and add 10 ml of ammonium hydroxide in excess. Make up the volume to 250 ml with distilled water.

13.1.3 Carry out a blank by adding 1 ml of sulphuric acid in a crucible and heating it over a low flame until dense white fumes are no longer evolved. Digest the residue with 20 ml of distilled water and 5 ml of sulphuric acid by heating to boil for about 5 minutes. Cool it and neutralize with ammonium hydroxide and add 10 ml of ammonium hydroxide excess. Make up the volume to 250 ml with distilled water.

13.1.4 Take 50 ml of solution obtained as in **13.1.2** in a 100 ml Nessler tube. Add 1 ml of gum Arabic solution and 10 ml of sodium diethyl dithiocarbamate solution, mix thoroghly and keep it for comparison.

13.1.5 Take 50 ml of blank solution obtained as in **13.1.3** in a 100 ml Nessler tubes. Add to it a known quantity of standard copper solution from a 10 ml burette. Add 1 ml of gum Arabic solution and 10 ml of sodium diethyl dithiocarbamate solution, mix thoroughly and compare the colour of the solution with the colour of the extract (*see* **13.1.4**).

NOTES

1 The amount of standard copper solution to be added will depend upon the colour produced by the extract. If the colour in the sample tube is too light for a good comparison, the amount of copper present on the basis of 10 g test specimen is below the sensitivity of the method Best results would be obtained when the aliquot contains copper equivalent to 1 to 5 ml of standard copper solution.

2 If necessary, water may be aded to the tube containing extract to make the volume equal to that of the tube containing the standard solution.

13.1.6 *Calculation*

Calculate the copper content of the test specimen by the following formula:

$$C = \frac{A \times 0\cdot 001 \times 5}{B}$$

where

C = copper content, in percent by mass;

A = volume, in ml, of standard copper solution; and

B = mass, in g, of the test specimen.

13.1.7 Repeat the test with the remaining test specimens and calculate the copper content of each test specimen.

13.1.8 Calculate the average of the results obtained as in **13.1.6** and **13.1.7** and report it as the copper content of the sample.

NOTE — Alternatively the test specimen may be ashed as given in **13.1.9**

13.1.9 Take a test specimen weighing about 10 g. Weigh it accurately to the nearest mg. Transfer the test specimen to a 90 ml porcelain crucible. Place the crucible on a low flame and protect it from strong drafts. Volatilie the organic matter gently taking care that the material does not burn with a flame. Continue heating till a carbonaceous skeleton is left.

13.2 Estimation of Salicylanilide Content

13.2.1 *Reagents*

13.2.1.1 *Potassium bromate-bromide solution*

The solution 0.1 N, is prepared by disolving 2.784 g of potassium bromate and 10 g of potassium bromide in sufficient amount of water and making up the volume to one litre.

13.2.1.2 *Hydrochloric acid*, 4 N.

13.2.1.3 *Potassium iodide solution*

The solution 1 N, is prepared by dissolving 166.028 g of potassium iodide in sufficient amount of water and making up to one litre.

13.2.1.4 *Standard sodium thiosulphate solution*, 0.1 N.

NOTE — The normality of sodium thiosulphate should be checked before use.

13.2.1.5 *Starch solution*

The solution is prepared by dissolving 1 g of soluble starch in 100 ml water.

13.2.1.6 *Sodium hydroxide solution*, 5 percent.

13.2.2 *Procedure*

13.2.2.1 Take a test specimen weighing about 10 g. Weigh it accurately to the nearest mg. Put the test specimen in the conical flask and heat it with 100 ml of sodium hydroxide solution for two hours at about 90°C on a water bath. Filter the extract and wash the residue twice with hot water and once with cold water. Collect the washings and the filtrate and make up to 250 ml with distilled water.

13.2.2.2. Take 25 ml of the extract in a 500 ml stoppered flask. Add to it 50 ml of potassium bromate-bromide solution and 30 ml of 4 N hydrochloric acid. Keep the flask in a cold water-bath at 15°C for half an hour with occasional shaking. Add 30 ml of potassium iodide solution to the flask. Keep it for five minutes and titrate the liberated iodine against sodium thiosulphate solution using starch solution as indicator.

13.2.2.3 Carry out a blank simultaneously following the procedure prescribed in **13.2.2.2** but taking 25 ml of water instead of extract.

13.2.3 *Calculation*

Calculate the salicylanilide content in the test specimen by the following formula:

$$S = \frac{(V_1 - V_2) \times 0\cdot 003\,55 \times 1\,000}{M}$$

where

S = salicylanilide content, percent, by mass;

V_1 = volume, in ml, of 0.1 N sodium thiosulphate required for extract (*see* **13.2.2.3**); and

V_2 = volume, in ml, of 0.1 N sodium thiosulphate required for extract (*see* **13.2.2.2**); and

M = mass, in g, of the test specimen.

13.2.4 Repeat the test with the remaining test specimens and calculate the salicylanilide content in each test specimen.

13.2.5 Calculate the average of the results obtained as in **13.2.3** and **13.2.4** and report it as the salicylanilide content of the test sample.

14 ESTIMATION OF *p*-NITROPHENOL

14.1 Reagents

14.1.1 *Standard p-Nitrophenol Solution*

The solution is prepared by dissolving 0.25 g of *p*-nitrophenol in 1 ml of 2 N sodium hydroxide solution and made up to 250 ml with water.

14.1.2 *Acetic Acid,* 2 N.

14.1.3 *Sodium Hydroxide Solution,* 2 N and 0.1 N.

14.1.4 *Ortho-cresol Solution,* 1 percent (*m/m*), freshly prepared in sufficient alkali (0.1 N) (*see* **14.1.3**).

14.1.5 *Zinc Dust*

14.2 Procedure

14.2.1 Take a test specimen of about 5 g weighed accurately to the nearest mg.

14.2.2 Extract the test specimen with 100 ml of 0.1 N sodium hydroxide solution for one hour at boil. Cool the extract, filter it and make up the volume to 250 ml.

14.2.3 Take 25 ml of the extract in a flask. Add 10 to 15 ml of 2 N acetic acid and 1 g of zinc dust. Heat the solution on boiling water-bath for 2 to 3 minutes to initiate the reduction. Allow the solution to remain for one hour at room temperature. Filter the solution into a 100 ml measuring flask. Wash and make up the volume to 100 ml.

14.2.4 Take 10 ml of standard *p*-nitrophenol solution and treat it as in **14.2.3** and make up the volume to 100 ml.

14.2.5 Take 10 ml of solution obtained as in **14.2.3** and 1 ml of reduced standard *p*-nitrophenol solution (**14.2.4**) in two Nessler tubes. Add 5 ml of freshly prepared ortho-cresol solution to each. Make the solution in both the tubes sufficiently alkaline by adding 2 N sodium hydroxide solution. Shake well and allow to stand for one hour till blue colour develops. Add more alkali to ensure complete development of colour. Make up the volume in each Nessler tube to 50 ml and compare the colour visually.

NOTE — It would be necessary to prepare different standard *p*-nitrophenol solutions in different Nessler tubes for comparison. In case of dispute, optical density method should be prepared The optical density should be measured at wave-length of 615 nm

14.3 Calculations

Calculate the percentage of *p*-nitrophenol by the following formula:

$$P = \frac{A}{M}$$

where

P = percentage, by mass of *p*-nitrophenol;

A = volume, in ml, of the reduced standard *p*-nitrophenol solution required to match the colour of the test solution; and

M = mass, in g, of the test specimen.

14.4 Repeat the test with the remaining test specimens and calculate the percentage of *p*-nitrophenol in each test specimen and then determine the average of all the values.

15 ESTIMATION OF 2, 4-DINITRO-1-NAPHTHOL (DAN) AND 4, 6-DINITRO-ORTHO-CRESOL (DNOC)

15.1 General

15.1.1 The method is applicable to the determination of 2,4-dinitro-1-naphthol and 4, 6-dinitro-ortho-cresol in textile material provided that dyestuffs are absent which are soluble in diethylether. The preservative is extracted from the material by hot extraction with ammonia solution; the solution acidified and the nitrobody extracted with ether. The residue from the other extract is dissolved, reduced and treated with ferric chloride solution. The optical density of the coloured solution is measured on a suitable spectrophotometer at a wavelength of 470 nm.

15.2 Reagents

15.2.1 *Diethylether*

15.2.2 *2, 4-Dinitro-1-naphthol Standard Reference Solution*

The solution 0.250 g/l is prepared by dissolving 0.250 g 2, 4 -dinitro-1-naphthol reagent in 20 ml of sodium hydroxide (0.1 N) solution and diluting with water to 1 000 ml. 1 ml = 0.000 25 g.

15.2.3 *4, 6-Dinitro-ortho-cresol Standard Reference Solution*

The solution 0.250 g/l is prepared by dissolving 0.250 g of 4, 6-dinitro-ortho-cresol reagent in 20 ml of sodium hydroxide 0.1 N solution and diluting with water to 1 000 ml. 1 ml = 0.000 25 g.

15.2.4 *Zinc Dust*

15.2.5 *Acetic Acid 5 M Reagent Solution*

15.2.6 *Ammonia Solution (0.2 N)*, dilute 5 N reagent solution 25 times.

15.2.7 *Ferric Chloride*. — The solution 100 g/l, is prepared by dissolving 10 g of ferric chloride in water and making up to 100 ml .

15.2.8 *Hydrochloric Acid, Concentrated*, 36 percent (*m/m*) (11 N).

15.2.9 *Hydrochloric Acid, 5 N Reagent Solution*

15.2.10 *Lead Acetate Solution*

The solution, 100 g/l, is prepared by dissolving 10 g of lead acetate in water and making up to 100 ml.

15.2.11 *Sodium Hydroxide Solution (2.5 N)*, dilute 5 N reagent solution two times.

15.2.12 *Sodium Hydroxide Solution (0.1 N)*, dilute 5 N reagent solution fifty times.

15.3 Procedure

15.3.1 Extract 5.0 g of shreded textile under reflux with 50 ml to 75 ml of water containing 3 ml of 0.2 N ammonia solution.

15.3.2 Decant off the extract and repeat the extraction until the extract is colourless and gives no colour on addition of sodium hydroxide solution. Bulk the separate extract, filter if necessary and add 5 ml of 2.5 N sodium hydroxide reagent solution to extract and evaporate if necessary to about 100 ml. Neutralize the solution to *p*H 6 with acetic acid solution, add 10 ml of lead acetate solution and allow to stand for 1 hour. Filter and wash the precipitate with hot water, keeping the volume of water used for washing as low as possible.

15.3.3 Make the combined filtrate and washings distinctly acidic with hydrochloric acid 5 N reagent solution and extract with 50 ml of diethyl ether until the aqueous layer remains colourless on making alkaline with sodium hydroxide 2.5 N reagent solution. Combine the ether extracts and evaporate the ether to within a few ml of dryness, removing the last traces of ether without application of heat. Dissolve the extracted nitro body in 60 ml of hot water adding 1 ml of 0.1 N sodium hydroxide solution to the solution to prevent loss of nitro body. Place on a boiling water bath, maintained at the boil, add 1 g of zinc dust and 2 ml concentrated hydrochloric acid in that order and continue heating on the water bath for exactly 15 minutes, stirring occasionally and avoiding loss by spray.

15.3.4 Filter through Whatman No. 42 filter paper into a 250 ml volumetric flask and wash the zinc residue well with water. Add 2.5 ml of ferric chloride solution and make up to 25 ml with water. Mix well. If the solution shows the slightest turbidity it must be refiltered. Measure the optical density of the solution on a suitable spectrophotometer at a wavelength of 470 nm with water as a blank. The calculation of 2, 4-dinitro-1-naphthol (DAN) and 4, 6-dinitro-ortho-cresol (DNOC) content may be made from a previously prepared calibration graph.

15.4 Calibration

15.4.1 To a series of 250 ml beakers, add 20, 40 60 and 80 ml of the DAN or (DNOC) standard solution. To an empty beaker add 80 ml of water, neutralize each with hydrochloric acid 5 N solution and make all the solutions to approximately 80 ml with water. Heat to the boil and place on a water bath. Maintain at the boil, add to each 1 g of zinc dust and 2 ml hyprochloric acid (concentrated) in that order and continue heating on the water bath for exactly 15 minutes stirring occasionally and avoiding loss by spray.

15.4.2 Filter through Whatman No. 42 filter paper into a 250 ml volumetric flask and wash the zinc residues well with water. Add to each 2.5 ml of ferric chloride solution and make up to 250 ml with water. Mix well.

15.4.3 Measure the optical density of the solution at a wavelength of 470 nm using 5 mm cells with water in the reference cell.

15.4.4 Construct a graph by plotting optical density against concentration of preservative agent. The range covered by the details given in 0.01 to 0.40 percent.

16 ESTIMATION OF DDT

16.1 Reagents

16.1.1 *Ethyl Ether*

16.1.2 *Ethanolic Potassium Hydroxide Solution*, 1 N.

16.1.3 *Acetone*

16.1.4 *Nitric Acid*, 2 N.

16.1.5 *Standard Silver Nitrate Solution*, 0.5 N.

16.1.6 *Ferric Alum*, 10 percent (*m*/*v*).

16.1.7 *Standard Potassium Thiocyanate Solution*, 0.05 N.

16.1.8 *Nitrobenzene*

16.2 Procedure

16.2.1 Draw one test specimen of about 10 g weighed accurately to the nearest mg.

16.2.2 Extract the specimen in the Soxhlet apparatus for four hours with ethyl ether at the rate of 10 to 12 extractions per hour.

16.2.3 Evaporate the ether off the extract and add 50 ml acetone and 20 ml of 1 N ethanolic potassium hydroxide. Keep at 20 to 25°C for 15 minutes and add 50 ml of distilled water. Add 20 ml of 2 N nitric acid and exactly 25 ml of 0.5 N standard silver nitrate solution. Shake, add 2 ml of nitrobenzene, shake again, add 2 m1 of 10 percent ferric alum solution and titrate the standard excess silver nitrate with 0.05 N standard potassium thiocyanate solution.

16.2.4 Carry out a blank titration side by side.

16.3 Calculations

16.3.1 Calculate the percentage of DDT present in the material using the following formula:

$$P = \frac{(V_2 - V_1) \times N \times 100 \times 0\cdot3546}{M}$$

where

P = percentage of DDT, by mass in the test specimen;

V_2 = volume, in ml, of potassium thiocyanate solution required for blank titration (*see* **16.2.4**);

V_1 = volume, in ml, of potassium thiocyanate solution required for the titration of excess of silver nitrate solution (*see* **16.2.3**);

N = normality of standard potassium thiocyanate solution; and

M = mass, in g, of the test specimen.

NOTE — Hydrolysable chlorine in DDT is 10 percent by mass

16.4 Repeat the test with the remaining test specimens and calculate the percentage of DDT in each test specimen and then determine the average of all the values.

17 ESTIMATION OF PENTACHLORO PHENYL LAURATE (PCPL)

17.1 General

The method is applicable to the determination of pentachlorophenyl laurate in the absence of added pentachlorophenol. The proofing is hydrolyzed, acidified and steam distilled and the pentachlorophenol in the distillate extracted with 1, 1, 1-trichloroethane and complexed with copper sulphate-pyridine reagent. The optical density of the complex in 1, 1, 1-trichlorethane is measured on a suitable spectrophotometer at 450 nm. If pentachlorophenol is believed to be present in an amount greater than 10 percent pentachlorophenol laurate then the procedure described should be carried out in conjection with that described in **8**.

17.2 Reagents

17.2.1 *Ethanediol* (*Ethylene Glycol*)

17.2.2 *1, 1, 1-trichloroethane* (*referred to here-after as trichloroethane*)

17.2.3 *Pyridine*

17.2.4 *Sodium Hydroxide Pellet*

17.2.5 *Sodium Sulphate, Anhydrous*

17.2.6 *Copper Sulphate Reagent Solution*, 50 g/l

17.2.7 *Pentachlorophenol* (*standard reagent*), recrystallized melting point 188°C minimum.

17.2.8 *Hydrochloric Acid*, concentrated 36 percent (*m/m*) (11 M)

17.3 Procedure

17.3.1 Weigh 2.5 ± 0.05 g of the material cut into small pieces of not more than 5 mm square and place in a dry 250 ml round bottom flask (B24/29 socket). Add 30 ml of ethanediol, 4 g of sodium hydroxide (pellet form), 2 ml to 4 ml of water, in that order and a few anti-bumping granules. Connect the flask with a double surface condenser, bring the contents to boiling point on a sand bath and boil them vigorously for 30 minute under reflux.

17.3.2 At the end of this period allow the contents of the flask to cool, remove the reflux condenser and carefully add through a funnel 60 ml of water followed by 20 ml of hydrochloric acid. Steam distill the contents of the flask ensuring that a constant volume is maintained by applying gentle heat as necessary. Collect 300 ml of distillate in a suitable receiver, applying particular care to prevent loss of perchlorophenol in the distillate by having adequate cooling. Discontinue the external heating of the flask a few minutes before disconnecting steam supply. Disconnect the condenser and fit it vertically over the distillate receiver. Wash down the condenser with 25 ml to 30 ml trichlorethane and collect the washings in distillate. Transfer the distillate and trichlorethane washings to a 500 ml separating funnel and shake thoroughly. Allow the layers of water and trichloroethane to separate completely before running off the trichloroethane layer into 100 ml separating funnel. Wash the condenser and distillate receiver with a further 25 ml to 30 ml trichloroethane and add this to aqueous solution in the 500 ml separating funnel. Repeat the extraction as previously described and add the trichloroethane layer to the first trichloroethane extract in the 100 ml separating funnel. Add to the bulked trichloroethane extract 10 ml of copper sulphate-pyridine reagent (prepared by mixing 4 ml of pyridine with 6 ml of copper sulphate solution immedately before use) and shake well. After effecting complete separation of the aqueous and trichloroethane layer run the lower trichloroethane layer into a 100 ml volumetric flask via a small funnel containing anhydrous sodium sulphate supported by means of quartz wool plug. Add a small quantity of trichloroethane to the copper sulphate-pyridine solution remaining in the separating funnel, shake and allow the layers to separate before filtering the trichloroethane layer through the quartz wool and collect in the volumetric flask. Wash the filter with further small quantities of trichloroethane and finally make up to 100 ml trichloroethane.

17.3.3 Determine the optical density of the solution using a suitable spectrophotometer at wavelength of 456 nm using trichloroethane as blank. Estimate the pentachlorophenyl laurate content by reference to a calibration graph prepared from known standard of pentachlorophenol (1.0 percent pentachlorophenol = 1.7 percent pentachlorophenyl laurate.)

NOTE — If the proofing is expected to contain both pentachlorophenol and the ester then the free pentachlorophenol content should be determined as described in **8** and the amount found deducted from the apparent pentachlorophenyl laurate content.

17.4 Calibration

17.4.1 *Direct*

Prepare a calibration graph using 5, 10, 15 ml aliquots of a standard solution of pentachlorophenol reagent in trichloroethane (1 g/200 ml) to cover a range of 1, 2 and 3 percent respectively. Dilute each aliquot to 50 ml to 60 ml with trichloroethane, add 10 ml of copper sulphate pyridine reagent, shake well and then follow the described procedure. Plot optical density against concentration of pentachlorophenyl laurate.

17.4.2 *Indirect*

Prepare a calibration graph using 5, 10 and 15 ml aliquots of a standard solution of pentachlorophenol reagent (1 g/200 ml) in dilute sodium hydroxide (only sufficient hydroxide solution to ensure complete solution of the pentachlorophenol is necessary). Place each aliquot in a round bottomed flask, add 60 ml of water and 20 ml hydrochloric acid. Fit the flask for steam distillation and then follow the described procedure, if the distillation technique is satisfactory then the graph obtained by the procedure described under direct (*see* **17.4.1**) and indirect should be the same.

18 ESTIMATION OF PERMETHRIN

18.1 General

18.1.1 This test method is applicable for estimation of permethrin applied in wool fabrics for its protection from insect damage. Permethrin is extracted from the wool fabric into solution. This extract, at a known dilution is then injected to the Gas Liquid Chromatographic apparatus (GLC) under specified conditions. The result of the analysis is then compared with standard known solution of permethrin, obtained under the same conditions.

18.2 Procedure

18.2.1 Weigh a sample of mothproofed wool fabric of 10 g after conditioning for 12 h at 27°C and 65 percent relative humidity. Transfer it to a Soxhlet extraction apparatus and extract for 6 h at a rate of six solvent exchange per hour with 100 ml of 2-methoxyethanol solvent in round bottom flask. Evaporate the extract to dryness and dissolve the extract in 5 ml of hexane and transfer to 10 ml volumetric flask. Rinse the round bottom flask with 5 ml hexane and transfer it to volumetric flask and make up to the mark.

18.2.2 To prepare standard solutions of known concentrations, dissolve accurately weighed quantity of permethrin (technical) in a suitable volume of isopropanol. From this stock solution prepare standard solutions of desired concentration by dilution with isopropanol in volumetric flask (10 ml).

18.2.3 Inject 2 or 3 μl of standard solutions (obtained in **18.2.2**) and then of extract sample (obtained in **18.2.1**) into the GLC operated under the conditions given in **18.2.4**. Thus obtain the chromatographs for standard solutions (known concentrations) and for the extract sample (unknown).

18.2.4 *Operating Conditions*

18.2.4.1 The operating conditions of the GLC with Flame Ionization Detector shall be as follows:

Column	– Glass column, 2 percent OV-17 on chromosorb AW DMCS, 1 metre (length) × 3 mm (internal diameter)	
Temperatures	– Oven	– 263°C
	Injector	– 290°C
	Detector	– 290°C
Gas flow rates	– N_2	– 76 ml/min
	– H_2	– 40 ml/min
	– Air	– 300 ml/min
Attenuation	– × 8	
Chart speed	– 5 mm/min	
Retention time	– 250 seconds	
Analysis time	– 18 minutes	

NOTE — A typical gas chromatographic run showing retention time and shape of the peak is given in Fig 1

18.2.5 Measure the peak areas of the standard solutions of permethrin and draw a calibration graph by plotting peak areas against the known concentrations.

18.2.6 Measure the peak areas of the extract sample and convert into a concentration by using calibration graph (obtained in **18.2.5**). Then calculate quantity of permethrin present in the total extract sample (10 ml) (obtained in **18.2.1**).

18.2.7 The percentage of permethrin present on the wool weight is determined by using the following formula:

$$\text{Permethrin, present (on wool weight)} = \frac{100 \times QPE}{WWF}$$

where

QPE = calculated quantity of permethrin present in the extract sample, and

WWF = weight of wool fabric taken for extraction.

18.2.8 Repeat the test with the remaining test samples and calculate the percentage of permethrin on the wool sample and then determine the average of all the values.

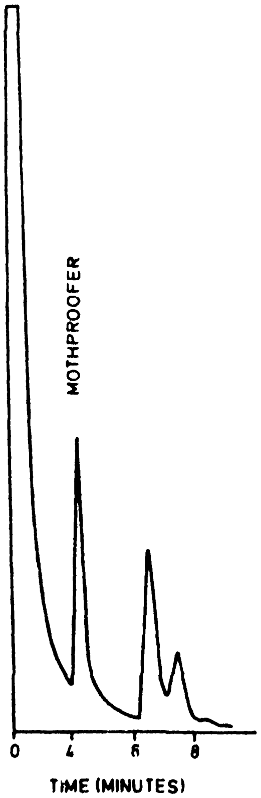

FIG. 1 GC CHROMATOGRAPH OF MOTHPROOFER

19 ESTIMATION OF 2-PHENYLPHENOL (OPP)

19.0 Principle

2-phenylphenol is extracted from the textile by steam distillation. An aliquot of the extract is treated with diazotized sulphanilic acid which forms a soluble coloured complex with 2-phenylphenol. The optical density of the complex is measured on a suitable spectrophotometer at 460 nm.

19.1 Reagents

19.1.1 *Orthophosphoric Acid* – 90 percent (*m/m*).

19.1.2 *Sodium Hydroxide* – 80 g/l solution.

19.1.3 *Sodium Hydroxide* – 10 g/l solution.

19.1.4 *Sodium Nitrite* – (0.05 M solution), prepared by dissolving 0.85 g sodium nitrite in water and making up to 250 ml with water. The solution should be prepared fresh before use.

19.1.5 *Sulphanilic Acid* – 0.5 M solution (approx), prepared by dissolving 1.91 g of sulphanilic acid in 250 ml of water.

19.1.6 *Sulphuric Acid* – (4.5 M), carefully dilute sulphuric acid concentrated 98 percent (*m/m*) to four times.

19.1.7 *Diazotized Sulphanilic Acid Solution* – This solution should be prepared immediately before use by adding 1 volume of sulphuric acid 4.5 M to 5 volumes of sulphanilic acid solution, cooling to 10°C and slowly adding to the solution 5 volumes of the sodium nitrite solution.

19.1.8 *2-Phenylphenol Standard Solution* (*1 g/l*) – prepared by dissolving 0.100 g of the reagent in 100 ml of the sodium hydroxide (10 g/1) solution and made up to 100 ml in a standard flask with sodium hydroxide. 2 -phenylphenol standard reference solution, prepared by diluting 10.0 ml of the standard solution (1 g/1) with sodium hydroxide (10 g/1) solution to 100 ml. 1 ml = 100 µg 2-phenylphenol.

19.2 Procedure

19.2.1 Weigh 5.0 g of the material, cut into small pieces of not more than 5 mm square and place in a 500-ml round bottomed flask, with a suitable glass ground socket. Add 200 ml of water and 3 ml orthophosphoric acid reagent. Connect the flask for steam distillation and steam distill the contents of the flask, ensuring that a constant volume is maintained by applying gentle heat as necessary. Collect 500 ml of the distillate, taking precautions to prevent the distillate becoming warm at any stage of the distillation.

19.2.2 Make up the volume of distillate to a known volume by addition of water. If the volume of distillate is 500 ml, take a suitable aliquot of not greater than 25 ml, dilute with water to 30 ml, add 10 ml of the diazotized sulphanilic acid solution followed by 5 ml of sodium hydroxide (80 g/1) solution and make up to 50 ml with water. Allow to stand for 1 hour, then determine the optical density of the solution on a suitable spectrophotometer at 460 nm using water as a blank. Estimate the 2-phenylphenol content by reference to a calibration graph made from known standards of 2-phenylphenol (*see* **19.2.3.2**).

19.2.3 Transfer by burette 1.0, 2.0, 3.0, 4.0, 5.0, 6.0 and 7.0 ml of 2-phenylphenol standard reference solution to a series of 50-ml standard flasks. To each of the seven flasks and to an empty flask add water to bring the total volume to 30 ml. Then add 10 ml of the diazotized sulphanilic acid reagent followed by 5 ml of the sodium hydroxide (80 g/1) solution and make up to 50 ml with water.

19.2.3.1 Allow to stand for 1 hour and determine the optical density of the solutions at 460 nm using the sample containing no 2-phenylphenol in the reference cell.

19.2.3.2 Draw a graph by plotting optical density against concentration of 2-phenylphenol.

NOTE — The range of the method is 0.01 percent to 1.4 percent 2-phenylphenol.

20 ESTIMATION OF TRIBUTYLTIN OXIDE (TBTO)

20.0 Principle

The material is subjected to wet oxidation, the tin in acid solution is solvent extracted. The tin is extracted from the organic solvent and the colour developed with catechol violet is measured by a suitable spectrophotometer at a wavelength of 552 nm.

20.1 Reagents

20.1.1 *Toluene* – low in benzene.

20.1.2 *Ammonia Solution* – 5 M reagent.

20.1.3 *Ascorbic Acid* – 5 percent (50 g/l aqueous reagent solution) – The solution should be prepared freshly.

20.1.4 *Hydrochloric Acid* – 5 M.

20.1.5 *Potassium Iodide* – 5 M (830 g/l) reagent solution prepared by dissolving 83 g potassium iodide in 70 ml water, then diluting to 100 ml with water. The solution should be prepared freshly.

20.1.6 *Sodium Hydroxide* – 5 M.

20.1.7 *Sodium Acetate Trihydrate* – 200 g /l reagent solution. Reagent to be free of fungal growth.

20.1.8 *Sodium Hydroxide* – 0.1 M.

20.1.9 *Sulphuric Acid Concentrated* – 98 percent (*m/m*), 18 M.

20.1.10 *Sulphuric Acid* – 4.5 M.

20.1.11 *Nitric Acid Concentrated*, 70 percent (*m/m*) (16 M).

20.1.12 *Tin (IV) Stock Solution* – 0.20 mg/ml Sn, prepared by dissolving 0.100 g pure granulated tin in 20 ml concentrated sulphuric acid. Heat until fumes appear then, cool before cautiously diluting with 150 ml of water. Cool again before adding 65 ml sulphuric acid concentrated, cool and transfer to a 500 ml volumetric flask and make up to volume with water.

20.1.13 *Tin (IV) Standard Reference Solution* – 10.0 µg/ml Sn, prepared by diluting 5.0 ml of Tin (IV) stock solution to 100 ml with water. This solution should be prepared when required.

20.1.14 *Catechol Violet* – 0.05 g/100 ml in water. This solution should be freshly prepared.

20.2 Procedure

20.2.1 Weigh accurately 1.0 g of the material, transfer to a 200-ml Kjeldahl flask, add 10 ml of sulphuric acid concentrated followed by the addition of nitric acid (16 M) 1-2 ml at a time. Apply gentle heat and digest with the further addition of nitric acid (16 M) until all organic matter is completely destroyed. Evaporate until fuming; cool, add 10 ml of water and boil to remove nitric fumes, evaporate again until fuming. Cool, add 30 ml water.

20.2.2 If the tin content is expected to comply with the light process (or less than 0.05 percent tin) transfer the solution, filtered if necessary, to a 100-ml graduated flask using sulphuric acid (4.5 M) and dilute to the mark with this acid.

20.2.3 If the tin content is expected to comply with the normal process (or greater than 0.05 percent tin) transfer the solution, filtered if necessary to a 250-ml graduated flask using sulphuric (4.5 M) and dilute to the mark with this acid.

20.2.4 Take a suitable aliquot of solution prepared as in **20.2.2** or **20.2.3** of not greater than 25 ml and not containing greater than 40 µg of tin and transfer to a 50-ml separating funnel. Add 2.5 ml potassium iodide (5 M) solution, mix and add 10 ml toluene. If, however, the volume of test solution taken exceeds 25 ml, add 1.0 ml potassium iodide for each 10.0 ml solution in excess of 25 ml. Insert the stopper, shake the funnel vigorously for 2 minutes, allow the layers to separate and discard the aqueous phase. Wash the toluene layer by swirling but without shaking with 5 ml of a solution prepared by mixing 25 ml sulphuric acid (4.5 M) and 2.5 ml potassium iodide solution. Discard the washing (After each of the operations using potassium iodide, wash below the separating funnel tap with water. It is advisable to rinse the funnel exit tubes free of potassium iodide since failure to do so may create unsightly stains following subsequent shaking). Add 5 ml of water to the toluene extract and then sodium hydroxide (5 M) solution dropwise with thorough shaking until the toluene layer is colourless. (This usually requires six to ten drops of the reagent), (add a further two drops of sodium hydroxide (5 M) reagent, insert the stopper and shake the funnel for 30 seconds. Allow the layers to separate and run the aqueous layer into a 50 ml beaker, ensuring that all liquid below the tap is transferred to the beaker. Add 3 ml sodium bydroxide (0.1 M solution) to the toluene layer, stopper the funnel then invert and shake for 30 seconds. Allow the layers to separate and add the aqueous layer to the contents of the 50 ml beaker. Retain the toluene layer.

20.2.5 Acidify the aqueous layer in the beaker with 2.5 ml hydrochloric acid and decolorize the liberated iodine by the dropwise addition of ascorbic acid solution. Add 2.0 ml catechol violet solution and mix. Wash the toluene layer retained in **20.2.4** by swirling (but without shaking) with 5 ml sodium acetate solution. Add these washings to the contents of the beaker, mix and adjust the *p*H of the solution to 3.8 ± 0.1 with ammonia solution by means of a *p*H meter. Transfer the solution to a 25-ml standard flask, dilute to the mark with water, and allow to stand for 30 minutes. Measure the optical density of the solution on a suitable spectrophotometer at a wavelength of 552 nm using a 10 mm cell.

20.3 Calculation

20.3.1 Calculate the tin content by reference to a calibration graph prepared from known standards of tin.

20.4 Calibration

Transfer by microburettes 0.5, 1.0, 1.5, 2.0, 2.5, 3.0 and 4.0 ml of tin (IV) standard reference solution to a series of 50-ml beaker. To each of these beakers and also to an empty 50-ml beaker add water to bring the total volume to 7.0 ml. To each, add in the order indicated (which must be strictly adhered to) the following reagents: 1.0 ml sodium hydroxide (5 M) solution mix; 2.5 ml hydrochloric acid solution, mix; 2.0 ml catechol violet solution, mix again; then add 5.0 ml sodium acetate solution. Adjust the *p*H of the solution to 3.8 ± 0.1 with ammonia solution using a *p*H meter. Transfer each solution to separate 25-ml standard flasks, dilute each to the mark with water and allow to stand for 30 minutes. Measure the optical density of each of the solutions in a 10-mm cell at 552 nm with the solution containing no tin in the reference cell. Construct a graph relating the optical density against concentration of tin.

NOTE – The graph should be rectilinear and pass through the origin. Since not all batches of catechol violet behave with equal sensitivity towards tin, recalibration is advised when a different batch of catechol violet is used.

21 ESTIMATION OF HALOGENATED DIPHENYL UREA DERIVATIVE (HDUD)

General

The method is applicable to the determination of HDUD on wool or on the woollen portion of blends of wool with nylon. It can also be used for blends of other animal fibres with nylon.

21.1 Principle

21.1.1 If no fibre other than wool (or other animal fibre) is present, the textile to be analyzed is dissolved in aqueous potassium hydroxide solution and the HDUD is hydrolyzed to form 3:4 dichloroaniline.

21.1.2 If the textile consists of a mixture of wool (or other animal fibre) and nylon, the woolen (or other animal fibre) part of the material to be analyzed is dissolved in an aqueous 50 percent potassium hydroxide solution and separated from undissolved nylon fibres. The HDUD is hydrolyzed to form 3:4 dichloroaniline.

21.1.3 The amine so obtained is isolated from the alkaline solution by steam distillation and is then diazotized and coupled with benzoyl-H-acid to form a red water-soluble dye. The amount of this dye is determined colorimetrically.

21.1.4 This method is not specific to HDUD. Other compounds, such as certain water -soluble dyes, can also produce a red, water-soluble dye by this method, which can, therefore, interfere with the HDUD determination. However, this has not been found to be a serious drawback in practice and the colorimetric method of estimation has been found to be reliable.

21.2 Apparatus

21.2.1 *Apparatus for the Separation of Wool and Nylon Fibres* – if required.

21.2.1.1 *Waterbath* – capable of maintaining at 175 mm × 30 mm boiling tube at 71 ± 1°C.

21.2.1.2 *Sintered glass funnel* – porosity grade 1.

21.2.1.3 *Buchner filter flask* – 500 ml capacity.

21.2.2 *Distillation Apparatus*

21.2.2.1 *Round bottom flask* – alkali resistant, of 1 000 ml capacity.

21.2.2.2 *Distillation splash head* – bulb diameter approximately 70 mm, fitted with a 19/9 ground glass joint on the base and a 24/10 ground glass joint at the end of the distillation tube.

21.2.2.3 *Bulb condenser* – fitted with a 24/10 ground glass socket. Length of the cooling jacket 25 to 30 cm.

21.2.2.4 *One-mark volumetric flasks* – 1 000 ml, 250 ml and 100 ml.

21.2.2.5 *Gas burner or electric heater*

21.2.3 *Water Bath* – capable of being controlled at 10 to 12°C.

21.2.4 *Spectrophotometer* – suitable for the measurement of absorbance (optical density) at a wavelength of 503 nm.

21.3 Reagents

21.3.1 *Potassium Hydroxide Solution* – 500 g/l.

21.3.2 *Potassium Hydroxide Solution* – 2.5 M.

21.3.3 *Hydrochloric Acid Solution* – 1.0 M.

21.3.4 *Sodium Hydrogen Carbonate Solution* – 1.0 M.

21.3.5 *Sodium Nitrite Solution* – 0.1 M.

21.3.6 *Benzoyl-H-Acid* - (that is, l-benzolyamino-8-hydroxynaphthalene-3, 6-disulphonic acid), 0.01 M solution. The solution should be renewed and stored in an amber coloured bottle.

21.3.7 3,4 - *Dichloroaniline* – 0.001 M standard solution. Weigh to the nearest 1 mg, 162 mg of 3,4 - dichloroaniline and dissolve in 10 ml of 1 M hydrochloric acid solution, heating, if necessary, on a boiling water bath until completely dissolved. Transfer the solution quantitatively to a 1 000 ml one-mark volumetric flask, dilute to the mark and mix well.

21.3.8 *High Vacuum Grease or Soft Paraffin* – for joint lubrication.

21.3.9 *Silicone Antifoam*

21.4 Procedure

21.4.1 *Dissolution of Wool or Other Animal Fibres*

21.4.1.1 *Wool and nylon mixtures*

If the textile material to be analyzed is a mixture of wool (or other animal fibre) with nylon, proceed as given in **21.4.1.2** to **21.4.1.5**.

21.4.1.2 Put 0.5 ± 0.001 g of the conditioned material to be analyzed into a boiling tube. Place the tube on the water-bath controlled at 71 ± 1°C and add 20 ml of the 500 g/l potassium hydroxide solution at about 20°C. Stir with a glass rod for exactly 5 min, within this period the wool dissolves. Filter immediately through the filter funnel into the Buchner filter flask and drain with suction. Rinse the boiling tube and the nylon residue three times with water, using a total of about 100 ml. To improve the rinsing effect, squeeze the residue with the help of tongs and then drain the filter crucible with suction.

21.4.1.3 Dry the nylon residue in the oven at 105 ± 2°C for 3 h, recondition and determine its mass to an accuracy of 0.001 g.

21.4.1.4 Transfer the filtrate to the distillation flask and rinse the Buchner filter flask with about 30 ml of water.

21.4.1.5 Add a few drops of the silicone antifoam and a few chips of unglazed porcelain to the dissolved wool solution in the distillation flask. Grease the ground glass joints with the high vacuum grease of soft paraffin and assemble the distillation apparatus. Place a 100-ml volumetric flask, containing 6 ml of the hydrochloric acid solution, together with a funnel under the condenser. Complete the estimation of HDUD as given in **21.4.2** to **21.4.5**.

21.4.1.6 *Wool and other animal fibres*

If no fibre other than wool (or other animal fibre) is present, proceed as given in **21.4.1.7**.

21.4.1.7 Place 0.5 ± 0.001 g of the conditioned material to be analyzed in a distillation flask. Add 140 ml of the 2.5 M potassium hydroxide solution together with a few chips of unglazed porcelain and a few drops of the silicone antifoam.

Complete the asembly of the apparatus as in **21.4.1.5** and the estimation of HDUD as given in **21.4.2** to **21.4.5**.

21.4.2 *Hydrolysis and Distillation*

Heat the contents of the distillation flask (obtained either in **21.4.1.5** or **21.4.1.7**) to the boiling point and maintain at the boiling point for 15 min. Then distil about 90 ml within 20 to 50 minutes. During distillation, ensure that neither the alkaline solution nor any foam passes through the distillation splash head into the condenser. Cool the distillate in the volumetric flask to 20°C, dilute to the mark and mix well.

21.4.3 *Diazotization*

Measure 50 ml of the contents of the 100-ml volumetric flask into a 250-ml volumetric flask and cool to 10 to 12°C (The remaining 50 ml of the distilate may be used for a check.). Add 1 ml of the sodium nitrite solution (0.1 M) and allow to stand for 10 min, protected from light, while cooling to 10 to 12°C.

21.4.4 *Coupling*

Add 15 ml of the sodium hydrogen carbonate solution (1.0 M) and, while shaking, add 3 ml of the benzoyl-H-acid solution. After 10 min, dilute the solution with water to 250 ml or to a volume more appropriate to the intensity of the colour of the solution.

21.4.5 *Colorimetric Determination of HDUD*

Measure the absorbance (optical density) of the solution in the spectrophotometer at wavelength of 503 nm against water in the reference cell and subtract the absorbance of the reagent blank. Determine the content of the HDUD in the tested sample from a calibration graph.

21.5 Preparation of the Calibration Graph

21.5.1 *Preparation of the Standard Solution*

To a series of six 1 000 ml round bottom flasks, transfer measured quantities of the standard 3,4 dichloroaniline solution shown in the following table:

Standard 3,4-Dichloroaniline Solution	*Corresponding Percentage of HDUD*[1]
ml	Percent
0[2]	0
4	0.22
8	0.45
12	0.67
16	0.90
20	1.12

21.5.2 *Colour Development*

Treat the contents of each flask as follows.

21.5.2.1 Dilute with approximately 30 ml of water and cool it to 10-12°C. Add 4 ml of the hydrochloric acid solution and 1.5 ml of sodium nitrite solution, shake well and cool once again to 10-12°C. Allow the solution to stand protected from light for 15 min and then add 15 ml of the sodium hydrogen carbonate solution and 3 ml of the benzoyl-H-acid solution. Shake, allow to stand for 10 min, transfer quantitatively to a 100 ml one-mark volumetric flask, dilute to the mark and mix well.

21.5.3 *Colorimetric Measurement*

After colour development, measure the absorbance of the standard solutions in the spectrophotometer at a wavelength of 503 nm against water in the reference cell.

21.5.4 *Plotting the Calibration Graph*

Deduct the absorbance of the reagent blank from those of the standard solution. Plot a graph having the percentage of HDUD as abscissae against the corresponding values of absorbance as ordinates.

21.6 Expression of Results

21.6.1 *Wool and Other Animal Fibres*

$$\text{HDUD percent} = \text{HDUD}_c \text{ percent}$$

where

HDUDC_c percent is the HDUD content as obtained from the calibration graph, and

HDUD percent is the HDUD content of a conditioned sample of the material.

21.6.2 *Wool/nylon mixtures*

$$\text{HDUD percent} = \frac{\text{HDUD}_c\% \times 0.5}{0.5 - gn}$$

where

HDUD_c percent is the HDUD content as obtained from the calibration graph,

HDUD percent is the HDUD content of the wool portion of a wool/nylon mixture sample, and

gn is the conditioned mass of the nylon part of a wool/nylon mixture as obtained in **21.4.1.3**.

22 ESTIMATION OF PHENOL CONTENT OF TEXTILES TREATED WITH TAR OIL

22.0 Principle

The phenols in a dried acetone extract of the material are determined by titration of the extract with a standard solution of potassium hydroxide in propane-2-ol. The test is based on the exothermic conversion of acetone to diacetone alcohol which is catalyzed by the free potassium hydroxide present at the end point.

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[1] Calculated on 5-chloro-2-(2-sulpho-4-chlorophenoxy)-3',4'-dichlor, N' N-diphenyl urea sodium salt, 1 H_2O (molecular weight 562.2).

[2] Reagent blank.

22.1 Apparatus

22.1.1 *Automatic Zero Burette*

100 ml capacity, 0.05-ml divisions, additional fine jet such as hypodermic needle to deliver 0.3-0.5 ml of titrant per minute with a full burette and tap fully open. The needle is connected to the burette by a short piece of flexible tubing to make a butt joint.

22.1.2 *PTEF Sleeve* — to prevent titrant attack on joint of burette.

22.1.3 *Titration Vessel* – 100-ml tall, form beaker.

22.1.4 *Thermometer* – 15 to 45 °C.

22.1.5 *Magnetic Stirrer* — with polyethylene or PTFE coated follower.

22.1.6 *Soxhlet Extraction Apparatus*, 60 ml capacity with 150 ml flask B19 neck.

22.1.7 *Liebig Condenser*, B19 Socket.

22.1.8 *Claisen Head*, B19 joints.

22.1.9 *Anti-bumping Glass Beads*

22.2 Reagents

22.2.1 *Acetone* (dry and free from acidity as possible).

22.2.2 *Benzoic Acid*

22.2.3 *Toluene*

22.2.4 *Potassium Hydroxide in Propan-2-ol* — (1 M) standard volumetric solution-prepared by dissolving 56 g of potassium hydroxide in dry propan-2-ol and diluting to 1 000 ml with propan-2-ol. Standardize the solution in the following manner.

22.2.4.1 Weigh accurately about 0.4 g of benzoic acid reagent and dissolve in 30 ml of acetone in the titration vessel. Titrate the solution with the potassium hydroxide solution by the method described under 22.3 until a steep temperature rise is obtained. Read the volume of potassium hydroxide used.

1 ml of 1 M potassium hydroxide solution = 0.122 g benzoic acid.

Let G be the mass of benzoic acid taken and × the quantity in ml of potassium hydroxide solution, then

$$\text{Concentration (M)} = \frac{G}{0{\cdot}122 \times X}$$

22.3 Procedure

Weigh accurately about 3 g of the material (more if the tar oil treatment is light) and place directly in the Soxhlet apparatus. Add 90 ml acetone to the flask and three glass beads (to prevent bumping) and extract for 2 hours or until the acetone becomes clear. After extraction is complete, allow the apparatus to cool then remove the flask and connect it to the condenser by means of the Claisen head. Distill off 50 ml acetone, add 30 ml toluene to the residual acetone extract in the flask and re-distil, reducing the volume of the extract to about 15 ml. Transfer the residual extract to the 100-ml beaker, and wash out the flask with small amounts of toluene. Transfer the washings to the extract in the beaker and add 50 ml of acetone. Place the follower and thermometer in the beaker and switch on stirrer. Fill the burette with the standardized potassium hydroxide solution, place the discharge end of the hypodermic needle (which is fitted to the automatic burette) below the surface of the contents of the beaker and start the addition of titrant by opening the burette tap fully, stirring continuously. Observe temperature and immediately a rise is evident, switch off the burette and read the volume of potassium hydroxide used (A). A blank titration experiment should be made using similar quantities of reagents as in the actual analysis to determine the correction for acidity in the reagents (B).

22.4 Calculation

$$P = \frac{(A - B) \times M \times 140 \times 100}{1\,000\, W}$$

where

P = percentage of phenol present,

A = ml of potassium hydroxide used,

B = ml of potassium hydroxide in blank titration experiment,

M = molarity of potassium hydroxide, and

W = mass of sample taken.

NOTE — 140 is taken as the average molecular weight of the phenols present

23 ESTIMATION OF DICHLOROPHEN 5,5'-DICHLOR 2,2' - DIHYDROXY DIPHENYLMETHANE

23.0 The method is applicable to the determination of dichlorophen in textile materials provided that other phenolic materials are absent.

23.1 Reagents

23.1.1 *4-Aminophenazone* — 10 g/l reagent solution, prepared by dissolving 1 g of reagent in 100 ml of buffer solution, *p*H 9.68.

23.1.2 *Buffer Solution* — *p*H 9.68 prepared by dissolving 13.75 g of disodium tetraborate and 1.125 g sodium hydroxide in water and diluting with water to 1 000 ml.

23.1.3 *Potassium Periodate* — 2.5 g/l reagent solution prepared by dissolving 1.25 g potassium periodate in 500 ml of the buffer solution, *p*H 9.68.

23.1.4 *Dichlorophen* — standard reference solution (20 µg/ml) — prepared by dissolving 0.200 g of dichlorophen, purified melting point 175°C in 10 ml acetone and diluting to 100 ml with the buffer solution.

10 ml of this solution diluted to 1 000 ml with buffer solution is 20 µg/ml.

23.2 Procedure — Extract 1 g of the proofed material (or sufficient to contain 10 mg dichlorophen) by boiling with four successive 25-ml lots of the buffer solution: each extraction should be allowed to continue for 7 minutes before decanting from the material. Combine the extracts, cool, add 100 ml buffer solution and make up to 200 ml with water. Filter a portion and take 4.0 ml and place into a 50-ml volumetric flask. Dilute to about 35 ml with buffer solution and add by pippette 1.5 ml of the 4-aminophenazone reagent. Mix thoroughly then add 10 ml of the periodate solution, dilute the solution with buffer solution to 50 ml and mix well. Control the temperature of the reaction within the range of 17-20°C, protect the solution from light and determine the optical density of the solution at 510 nm on a suitable spectrophotometer after not less than 5 minutes using a reagent blank as zero.

23.3 Calibration – Prepare standard solutions by taking 5,10 and 15 ml aliquots of the dichlorophen standard reference solution, 20 µg/ml, dilute to about 50 ml with buffer solution and proceed as described in **23.2**. Measure the optical density and plot the data on a graph, optical density against µg of dichlorophen.

23.4 Calculate the dichlorophen content from a previously prepared calibration graph (*see* **23.3**).

DETERMINATION OF BARIUM ACTIVITY NUMBER OF COTTON TEXTILE MATERIALS

(*Source* : IS 1689 : 1973)

Apart from lustre the absorption capacity of cotton is greatly increased by mercerization. Mercerized cotton absorbs soluble alkaline hydroxides to a greater extent than unmercerized cotton. Barium hydroxide is more readily absorbed by cotton cellulose than other alkalis and its absorption is convenient to measure. This barium hydroxide absorption test is thus indicative of the cotton material having undergone the process of mercerization. If unmercerized cotton is indicated by Barium Activity Number 100, the Barium Activity Number above 115 indicates that the sample under test has undergone the process of mercerization. This test can not be used satisfactorily on materials treated with durable finishes, or dyed with sulphuric dyes or if fibres other than cotton are present.

1 SCOPE

This standard prescribes a method for determination of barium activity number of cotton materials.

2 TERMINOLOGY

For the purpose of this standard, the following definition shall apply.

Barium Activity Number – The ratio of the quantity of barium hydroxide absorbed by mercerized cotton to that absorbed by unmercerized cotton under identical conditions, multiplied by 100.

3 PRINCIPLE

A sample is taken and completely freed from all sizing and finishing materials. It is treated with barium hydroxide to determine its absorption. The absorption of an unmercerized cotton sample is also determined under identical conditions. The ratio of absorption of test sample and unmercerized cotton sample is expressed as the barium activity number taking the unmercerized cotton as 100.

4 SAMPLING

4.1 Samples shall be selected so as to be representative of the lot.

4.2 Sample drawn as laid down in the material specification or in compliance with an agreement between the buyer and the seller shall be held to be representative of the lot.

4.3 In case of cotton fabrics, the sample shall be drawn in accordance with the procedure given in IS 5463 : 1969 'Methods for sampling of cotton fabrics for chemical tests' given in Section A-1/3.

5 TEST SPECIMENS AND CONTROL SPECIMEN

5.1 Test Specimens

5.1.1 If the sample under test is yarn, draw from it at least three specimens each weighing about 3 g.

5.1.2 If the sample under test is fabric, draw from it three specimens each weighing about 3 g and preferably square in shape.

5.2 Control Specimen

Draw from the basic (unmercerized, scoured) cotton material a specimen weighing about 3 g.

NOTE – If the basic (unmercerized) material is not available, an unmercerized (scoured) cotton material similar in construction to that under test shall be used for the control.

6 APPARATUS

6.1 Soxhlet Extractor

6.2 Drying-Oven

Capable of being maintained at a temperature of 105 ± 3°C.

6.3 Conical Flask — with stopper.

6.4 Pipette

7 REAGENTS

7.1 Unless specified otherwise pure chemicals shall be applied in the test. Distilled water shall be used where the use of water as a reagent is intended.

NOTE – 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the results of the analysis.

7.2 Chloroform

7.3 Diastase or Other Suitable Desizing Enzyme

7.4 Sodium Chloride

7.5 Soap-Soda Solution

Containing 20 g of soap and 10 g of anhydrous sodium carbonate per litre. The soap shall contain not more than 5 percent moisture and shall comply with the following composition, dry mass basis:

Free alkali (as Na_2CO_3), *Max*	0.3 percent
Free alkali (as NaOH), *Max*	0.1 percent
Combined fatty acids (as sodium salt), *Min*	85 percent
Titre of mixed fatty acids prepared from the soap, *Max*	30°C
Iodine value of fatty acids, *Max*	50

7.6 Barium Hydroxide Solution

Approximately 0.25 N.

7.7 Hydrochloric Acid

0.05 N and 0.1 N.

7.8 Phenolphthalein Indicator

Prepared by dissolving 0.5 g of phenolphthalein in 50 ml of ethyl alcohol and diluting to 100 ml with water.

8 PROCEDURE

8.1 Take one test specimen.

8.1.1 If the material under test is not heavily finished, desize the specimen as given in **8.1.1.1**, **8.1.1.2** or **8.1.1.3** depending on the type of ingredients used in the size or finish.

8.1.1.1 In case it is known that the material is sized or finished with a mixing containing starch but not tamarind kernel powder, dip the specimen in a solution (weighing 20 times the mass of the specimen) containing 5 g of diastase and 10 g of sodium chloride per litre at 70°C and at a *p*H of 6.5 to 7.7 (*see* Note). Allow the specimen to remain in the solution for one and a half hours. During this period, take it out from the desizing bath and wring it by hand at least three times. At the end of the period remove the specimen, wash it thoroughly four times in hot and cold water successively, using 50 ml of water for each wash.

NOTE — The temperature and *p*H given for the desizing solution are the optimum for bacterial diastase. If any other type of desizing enzyme is used, then the temperature and *p*H shall be modified to that recommended by the supplier. As many enzymatic desizing agents slowly deteriorate in storage, care shall be taken to see that the sample of desizing agent, at the time of test, has still satisfactory desizing efficiency.

If any doubt exists as to whether the size or finish has been completely removed, the treatment with the enzymatic desizing solution shall be repeated, the specimen being again weighed after drying to constant mass at 105 to 110°C and the percentage loss in mass again calculated. If the value for the percentage loss in mass has increased by not more than 0.25, then it may be considered that complete desizing has been effected, and the second value be accepted as the final value. If the value for the percentage loss in mass has increased by more than 0.25, then the desizing treatment should be repeated until the figure for percentage loss in mass does not differ from the previous figure by more than 0.25.

8.1.1.2 In case it is known that the material is sized or finished with a mixing containing tamarind kernel powder but not starch, boil the specimen in the soap-soda solution (weighing 20 times the mass of the specimen) for 45 minutes. Wash it thoroughly first in hot water and then in cold water.

8.1.1.3 In case it is known that the material is sized or finished with a mixing containing both starch and tamarind kernel powder or in case the ingredients used in the size or finish are not known, desize the specimen in the manner prescribed in **8.1.1.1** for the specimen known to contain starch and treat it further in the manner prescribed in **8.1.1.2** for the specimen known to contain tamarind kernel powder.

8.1.2 If the material under test is heavily finished with mineral oils and waxes or with salts, extract the specimen with chloroform in a Soxhlet extracting apparatus for one hour, and then desize the specimen as given in **8.1.1**.

8.1.3 Add bromocresol purple to the water extract of the sample and add dilute hydrochloric acid (0.05 N to 0.1 N) drop by drop till it turns yellow. Keep the solution for about 30 minutes. Remove the extract. Wash the sample with distilled water till it is free from acid.

8.2 Dry the specimen and expose it to room atmosphere for about 4 hours. Cut the specimen into small pieces. Take exactly 2 g (on oven-dry basis) of the specimen.

NOTE — For calculating the mass of mercerized and unmercerized cotton to be taken for the test, the values of actual regain used are as given below:

Mercerized cotton	9 percent
Unmercerized cotton	6 percent

8.3 Transfer the specimen to a 50-ml conical flask and add 30 ml of barium hydrodixe solution to it. Stopper the flask and allow it to stand for at least 2 hours, with frequent shaking. At the end of this period, pipette out 10 ml of the clear solution from the flask and titrate it with hydrochloric acid using phenolphthalein as indicator.

8.4 Make a blank determination following the same procedure (*see* **8.3**) but without the test specimen.

8.5 Treat the control specimen in a similar manner (*see* **8.1** to **8.3**) along with the test specimen.

8.6 Similarly test other test specimens.

9 CALCULATION

9.1 Calculate the barium activity number by the following formula:

$$\text{Barium activity number} \quad \frac{a-b}{a-c} \times 100$$

where

a = quantity in ml, of hydrochloric acid required for the blank (*see* **8.4**);

b = quantity in ml, of hydrochloric acid required for the test specimen (*see* **8.3**); and

c = quantity, in ml, of hydrochloric acid required for the control specimen (*see* **8.5**).

9.2 Calculate the barium activity number of other test specimens and determine the average of all values obtained.

10 REPORT

The report shall include the following information:

a) Type of material tested,

b) Number of test specimens, and

c) Barium activity number.

DETERMINATION OF COPPER NUMBER OF COTTON TEXTILE MATERIALS

(*Source* : **IS 200 : 1989**)

Textile materials are liable to deterioration by action of acids, oxidizing agents, heat, light and micro-organism during processing, wear and storage which lowers the quality of material. The estimation of copper number is recognized as a useful test. But for the judging the degree of deterioration of textile materials, the value becomes significant only when considered in conjunction with other tests, particularly that of cuprammonium fludity.

1 SCOPE

It prescribes two methods for the determination of copper number of cotton textile materials. The standard method is normally used for routine testing while the micro method is used for testing cotton textile materials when better accuracy is required.

2 PRINCIPLE

In both the methods, a known amount of cotton material is heated for 3 hours at 100°C with an alkaline solution of copper prepared from copper sulphate and a mixture of sodium carbonate and sodium bicarbonate. The cuprous oxide formed is dissolved in a solution of ferric alum and sulphuric acid, reducing an equivalent amount of iron to the ferrous state. The reduced iron is then determined by titration with standard solution of potassium permanganate or, preferably, with feric ammonium sulphate using phenylanthranilic acid as indicator.

3 TERMINOLOGY

Copper Number

The mass of copper in grams reduced by 100 grams of bone-dry cellulose from cupric to cuprous state in alkaline solution.

4 SAMPLING

Sample from the lot shall be drawn so as to be representative of the lot. Sample drawn in accordance with the procedure specified in the relevant material specification or as agreed to between the buyer and the seller shall be taken to be the representative of the lot.

5 PREPARATION OF TEST SPECIMENS

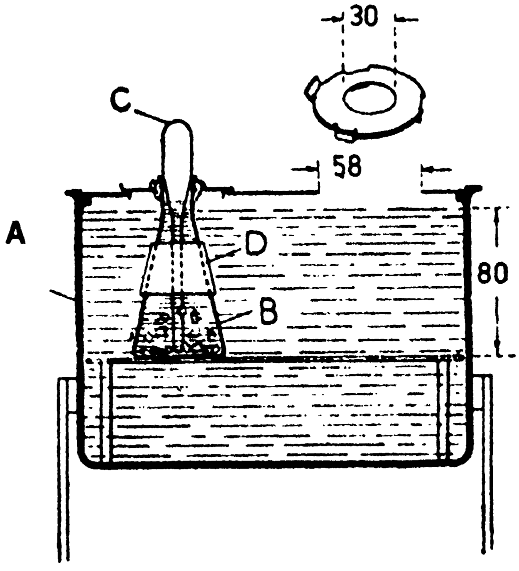
5.1 Remove the extraneous reducing matter, specially starches, and other finishes by the methods prescribed in IS 9068 : 1979 'Recommednded methods for the removal of non-fibrous matter prior to quantitative analysis of fibre mixtures'. Dye in the coloured fibre is considered to be an integral part of the fibre and is not to be removed.

5.2 Take some portion of the test sample and determine its moisture content by following the procedure given in IS 199:1989 'Methods for estimation of moisture, total size or finish, ash and fatty matter in grey and finished cotton textile materials (*third revision*)' given in Section D/25. Cut the other portion into small pieces of approximately 1.5 mm length and mix them thoroughly. Take at least 2 test specimens having oven-dry mass of 2.5 g weighed accurate to the nearest mg.

6 STANDARD METHOD

6.1 Apparatus

6.1.1 *Constant Level Water-Bath*, with perforated false bottom (*see* A in Fig.1).



All dimensions in millimetres.

FIG. 1 ARRANGEMENT OF APPARATUS

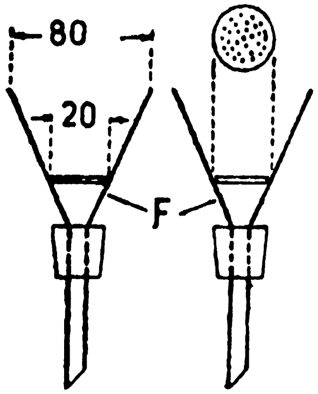
6.1.2 *Conical Flasks*, 100 ml (*see D* in Fig. 1).

6.1.3 *Combined Glass Stopper and Stirrer*, (*see C* in Fig.1).

6.1.4 *Load Sinkers*, to fit *B* (*see D* in Fig. 1).

6.1.5 *Filter Flasks*, two of 500 and 250 ml capacity, respectively, the necks of which should have the same internal diameter.

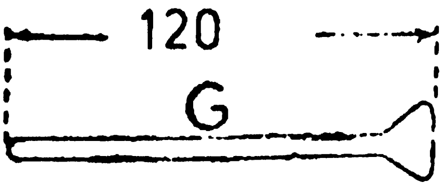
6.1.6 *Glass Funnel*, with sealed-in sintered glass plate or ordinary glass funnel and perforated porcelain plate (*see F* in Fig. 2). The stem of the funnel is provided with a rubber stopper to fit the flasks.



All dimensions in millimetres.

FIG. 2 FUNNEL AND FILTER PLATE

6.1.7 *Glass Squeezing Rod* (*see G* in Fig. 3).



All dimensions in millimetres.

FIG. 3 SQUEEZING ROD

6.1.8 *Buchner Funnel*

6.1.9 *Beakers*, 600 and 250 ml capacity.

6.2 Reagents

6.2.1 *Quality of Reagents*

Unless specified otherwise, pure chemicals shall be employed in tests and distilled water (*see* IS 1070) shall be used where the use of water as a reagent is intended.

NOTE — 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the test results.

6.2.2 *Solution A*

Add 130 g of anhydrous sodium carbonate slowly to about 750 ml of distilled water at about 70°C and stir until dissolved. Dissolve 50 g of sodium bicarbonate in this solution and then filter through a Buchner funnel and make the solution up to one litre.

6.2.3 *Solution B*

Dissolve 100 g of crystalline copper sulphate ($CuSO_4.5H_2O$) in distilled water and make the solution up to one litre.

6.2.4 *Solution C*

Dissolve 100 g of freshly ground ferric alum in about 500 ml of distilled water. Add 140 ml of concentrated sulphuric acid slowly with constant stirring and cooling, and dilute the whole to one litre with distilled water.

6.2.5 *Solution D*

Dilute sulphuric acid, 2 N (approx).

6.2.6 *Potassium Permanganate Solution* (0.04 N)

The solution is prepared as follows:

Dissolve about 1.27 g of potassium permanganate in distilled water. Dilute the solution to about 900 ml, boil for 15 min, cool and then filter by suction through a pad of pure asbestos fibre. After dilution to about one litre, standardize the solution against pure sodium oxalate and store in the dark in a well-stoppered bottle. It should be re-standardized at frequent intervals.

6.2.7 *Ceric Ammonium Sulphate Solution* (0.04 N)

$[Ce(SO_4)(NH_4)_2SO_4 2H_2O]$

It may be used as an alternative to potassium permanganate and is prepared as follows :

Take the required mass of ceric ammonium sulphate (*see* Note) in a 600 ml beaker, mix it with 50 ml of concentrated sulphuric acid and heat it gently, with stirring, until the acid just begins to fume. The product at this stage should be a lemon-yellow paste free from lumps, cool and dilute it by the cautious addition of about 500 ml of water. The salt disolves readily, and when the solution is cold, dilute it to one litre with water. This solution is stable but care should be taken not to store it in bottles whose surfaces have been etched in any way. The normality should be checked if the period of storage exceeds 2 months.

NOTE — The mass of the solid reagent required depends on its purity and shall be determined by a preliminary trial.

6.2.8 *Phenylanthranilic Acid Indicator*

Dissolve anhydrous sodium carbonate (0.13g) in a small quantity of hot water, add phenylanthranilic acid (0.266 g) to the solution, and then dilute to 250 ml.

6.2.9 *Ferrous Ortho-Phenanthroline*

Dissolve 1.49 g of ortho-phenanthroline monohydrate in 100 ml of water containing 0.7 g of hydrated ferrous sulphate.

6.3 Procedure

6.3.1 Place 2.5 g of the material, previously cut into small pieces, into flask *B*.

6.3.2 Run 5 ml of solution *B* from a pipette into 95 ml of solution *A* contained in a 250 ml lipped beaker and raise the mixture to the boil. Then pour immediately into flask *B* and mix thoroughly with the sample by means of a pear-bulb stirrer which afterwards serves as a loose stopper.

6.3.3 Weigh the flask by means of the load sinker and immerse to the neck in the bath; close it as completely as possible by means of a metal ring (*see* Fig. 1) and finally pack round the neck with a short length of cotton sliver. Allow the flask to remain in boiling water for 3 h and stir the contents occasionally during the first 15 min to release air bubbles. Transfer the liquor and fibre to the funnel *F* and filter by suction through two layers of filter paper (42.5 mm diameter) cut radially round the edges of facilitate fitting into the funnel. Wash the flask well, first with a dilute solution of sodium carbonate and then with hot water, and pour the washing over the sample. Press the sample thoroughly with a glass squeezing rod (*see* Fig. 3) and wash with further quantities of hot water. Reject the filtrate and washings which have collected in the larger filter flask.

6.3.4 Fit the funnel to the smaller filter flask and dissolve the cuprous oxide by treatment with successive portions of solution *C*; use the first portion to remove any adhering cuprous oxide from flask *B* before pouring into the funnel. Two portions of the solution, 15 ml and 10 ml respectively, usually suffice but an additional 10 ml may occasionally be necessary. Wash the material finally with successive 15 ml portion of solution *D*. Prior to each addition of solution *C* or *D* release the suction to ensure that the liquid saturates the fibrous material thoroughly before being drawn into the flask; the connection to the filter pump should be provided with a three-way tap for this purpose.

6.3.5 Titrate the solution either with 0.04 N potassium permanganate or preferably with 0.04 N ceric ammonium sulphate. If the latter oxidant is used, add four drops of phenylanthranilic acid indicator to the solution before titration. The colour of the solution then changes from pale green to brownish purple when oxidation of the ferrous iron is complete.

6.3.6 Ferrous-*o*-phenthroline indicator may be used, in which case the colour changes is from red to pale green. This indicator may also be used if the titration is carried out with potassium permanganate. Similar colour changes occur and the end point is much sharper than if no indicator is used.

One millimetre of 0.04 N solution corresponds to 0.002 543 g of copper.

6.4 Expression of Results

6.4.1 Calculate the copper number N_{cu} by the formula:

$$N_{Cu} = \frac{t \times f \times 0{\cdot}002\,543 \times 100}{2{\cdot}5 \times m}$$

where

t = the volume of 0.04 N solution (**6.2.6** or **6.2.7**) required,

f = the normality of the solution, and

m = the correction for moisture content.

NOTE — For most purposes, it is sufficient to assume an average moisture content, for example, 6 percent for cotton materials, m = 0.94.

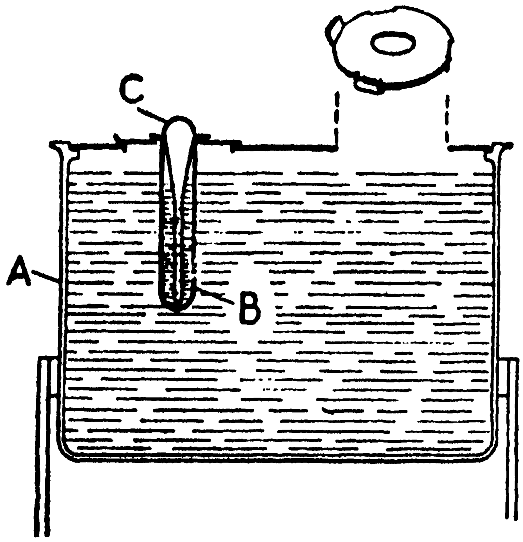
7 MICRO METHOD

7.1 Principle

The sample of known mass is heated for 3 h at 100°C with an alkaline solution of copper prepared from copper sulphate and a mixture of sodium carbonate and bicarbonate. The cuprous oxide formed is dissolved in a solution of iron alum and sulphuric acid reducing an equivalent amount of iron to the ferrous state. The reduced iron is then determined by titration with a standard solution of ceric ammonium sulphate using phenylanthranilic acid as indicator.

7.2 Apparatus

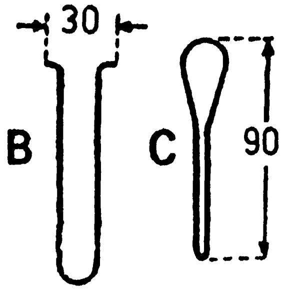
7.2.1 *Constant Level Water-Bath* (*see A* in Fig. 4).



All dimensions in millimetres

FIG. 4 LEVEL OF SUSPENDED TUBE IN WATER-BATH

7.2.2 *Glass Tubes*, 85 mm × 16 mm (internal) (*see B* in Fig. 4).



All dimensions in millimetres

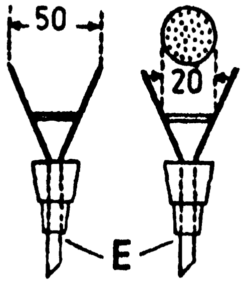
FIG. 5 STOPPER AND STIRRER COMBINED

7.2.3 *Combined Glass Stopper and Stirrer* (*see C* in Fig. 5).

7.2.4 *Filter Flasks*, 250 and 100 ml, respectively.

7.2.5 *Glass Funnel*

It shall be with sealed in sintered glass plate or ordinary glass funnel and perforated porcelain plate (*see E* in Fig. 6). The stem of the funnel is provided with two rubber stoppers to enable it to be fitted to either filter flask.



All dimensions in millimetres.

FIG. 6 ADAPTABLE FILTER FUNNEL

7.2.6 *Micro-Burette* (*10 ml*), graduated in fiftieths of a millilitre.

7.3 Reagents, same as in standard method.

7.4 Procedure

7.4.1 Place 0.25 g of the material, previously cut into small pieces into tube *B* (*see* Note).

NOTE — When sufficient material is available, a mass of about 2 or 3 g is cut into small pieces and mixed thoroughly before the sample is taken for analysis.

7.4.2 Run solution *B* (0.5 ml) from a pipette into 9.5 ml of solution *A* contained in a 60 ml lipped beaker, raise the mixture to the boil, pour immediately into the tube and mix thoroughly with the sample by means of a pear-bulb stirrer *C* which afterwards serves as a loose stopper.

7.4.3 Suspend the tube in the water bath to a depth such that the surface of the liquid in the tube is at or slightly below the level of the boiling water (*see* Fig. 4).

Stir the contents of the tube occasionally during the first 15 min to release air bubbles, and continue heating for a total period of 3 h. Transfer the liquor and fibre to the funnel *E* and filter by suction through two layers of filter paper (42.5 mm diameter) cut radially round the edges to facilitate fitting into the funnel. Wash the tube well, first with a dilute solution of sodium carbonate and then with hot water, and pour the washing over the sample. Then wash the sample with further quantities of hot water. Reject the filtrate and washings.

7.4.4 Fit the funnel to the smaller filter flask and dissolve the cuprous oxide by treatment with successive portions of solution *C*, use the first portion to remove any adhering cuprous oxide from the tube *B* before pouring into the funnel. Two portions of solution, 1.5 ml and 1.0 ml respectively, usually suffice but an additional 1.0 ml may occasionally be necessary. Wash the material finally with two successive 1.5 ml portion of solution *D*. Prior to each addition of either solution *C* or *D*, release the suction to ensure that the liquid saturates the fibrous material thoroughly before being drawn into the flask; the connection to the filter pump should be provided with a three-way tap for this purposes.

7.4.5 Titrate the solution with 0.01 N ceric ammonium sulphate after adding one drop of phenylanthranilic acid indicator; the colour of the solution changes from pale green to bright purple when oxidation of the ferrous iron is complete. Alternatively, ferrous-*o*-phenanthroline indicator may be used, the colour change then being red to pale green. One millilitre of 0.01 N ceric ammonium sulphate corresponds to 0. 0 006 357 g of copper.

7.5 Expression of Results

7.5.1 Calculate the copper number (N_{cu}) by the formula:

$$N_{Cu} = \frac{t \times f \times 0.0\,006\,357 \times 100}{0.25 \times m}$$

where

t = volume of 0.01 N ceric ammonium sulphate required,

f = normality of the ceric ammonium sulphate, and

m = correction for moisture content.

NOTE — For most purposes, it is sufficient to assume an average moisture content, for example, 6 percent for cotton materials (m = 0.94).

8 REPORT

The report shall include the following information:

a) Nature and type of textile material tested,

b) Copper number of the textile material tested,

c) Method (*see* 6 or 7) used, and

d) Number of tests performed.

DETERMINATION OF *p*H VALUE OF AQUEOUS EXTRACTS OF TEXTILE MATERIALS

(*Source* : IS 1390 : 1983)

The *p*H of aqueous extract of the textiles affords a useful index to its processing history. In addition, it is becoming more common to demand that the textile, in its various forms, shall conform to certain limits in respect of its acidity or alkalinity, often expressed in terms of *p*H values of aqueous extracts. The values obtained for the *p*H of the aqueous extract of samples of textiles, by the methods specified in this standard should not be used to give quantitative estimate of the acidity or alkalinity of the textile. Such an interpretation may be misleading, particularly for *p*H values less than 3 or greater than 11.

1 SCOPE

1.1 It prescribes methods for determination of *p*H value of aqueous extracts of textiles. The methods are applicable to textile in any form (fibres, yarns or fabrics) provided that a small representative sample may be obtained which is in or may be reduced to, a form which permits a ready exchange of liquid between the interior of the material and the water used in preparing the extract.

1.2 Two methods of preparation of aqueous extracts have been prescribed in this standard. For Kier-boiled or scoured and bleached textile materials which have not been finished, *p*H values of aqueous extracts prepared by the cold method and by the hot method would be the same. Hence any one of the methods may be followed. However, for finished or proofed fabrics the two values may differ depending upon the nature of finish or proofing of the fabrics; in such cases *p*H values of cold extract as well as hot extract should be separately determined.

2 PRINCIPLE

A specimen of the material under test is extracted with distilled or deionized water and the *p*H of the aqueous extract is determined electrometrically with the use of glass electrodes.

3 SAMPLING

3.1 Sample to determine the conformity of a lot to a specification shall be selected so as to be representative of the lot.

3.2 Sample drawn in compliance with an agreement between the buyer and the seller to evaluate *p*H value of the aqueous extract of the textile material shall be held to be representative of the lot.

4 PREPARATION OF TEST SPECIMENS

Take a laboratory sample representative of the bulk of the material and sufficient to provide all the test specimens required. Cut the laboratory test sample into pieces approximately 5 mm size or of dimensions such that the test samples will rapidly wet out. Manipulate the material as little as possible.

5 CONDITIONING OF TEST SAMPLE

Prior to test, the test sample shall be conditioned to moisture equilibrium in a standard atmosphere at 65 ± 2 percent ralative humidity and 27 ± 2°C temperature (*see* IS 6359:1971 'Method of conditioning of textiles' given in Section B-1/1).

6 APPARATUS

6.1 Glass Stoppered Flasks – made of chemically resistant glass for preparation of the aqueous extract.

6.2 Mechanical Shaker – providing a to and fro movement at a rate of 60 per minute or a rotational frequency of 30 per minute.

6.3 *p*H Meter – graduated in 0.1 unit of *p*H and with suitable electrode system.

6.4 Beakers – made of chemically resistant glass of capacity 250 ml.

6.5 Balance – accurate to 0.05 g.

6.6 Erlenmeyer Flask – made of chemically resistant glass and of 250 ml capacity fitted with a glass stopper.

6.7 Reflux Condenser

7 REAGENTS

7.1 **Distilled or Deionized Water** – having a *p*H between 6.5 and 7.0 and maximum conductivity of 2×10^{-6} S/cm[1] at 27 ± 2°C.

7.2 **Buffer Solutions** – of *p*H similar to that being determined, for standardization of *p*H meter before measurement. The solutions recommended are given in 7.2.1 and 7.2.2.

7.2.1 *Primary Standard* – potassium hydrogen phthalate ($HOOC.C_6H_4$ COOK), 0.05 mol/l, *p*H 4.00 at 15°C, 4.001 at 20°C, 4.005 at 25°C and 4.011 at 30°C.

7.2.2 *Secondary Standard* – disodium tetraborate decahydrate, ($Na_2B_4O_7.10H_2O$) 0.05 mol/l, *p*H 9.28 at 10°C, 9.21 at 20°C, 9.13 at 30°C and 9.06 at 40°C.

8 PROCEDURE

8.1 Preparation of the Aqueous Extract

8.1.1 *Cold Method*

Prepare the extract in triplicate at the temperature of laboratory (which shall be recorded) by taking a test specimen weighing 2 ± 0.05 g and 100 ml of the distilled or deionized water (*see* **7.1**) into a stoppered glass flask (*see* **6.1**). Agitate the flask for 20-30 min by hand to ensure that the specimen is properly wetted out, then shake it mechanically for 20-30 minutes (*see* **6.2**).

8.1.2 *Hot Method*

Rinse the Erlenmeyer flask with distilled or deionized water. Take one test specimen weighing 2 ± 0.05 g and add to this 100 ml of distilled or deionized water. Boil the contents for one hour under reflux condenser. Stopper the flask and cool the contents to room temperature.

8.2 Measurement of *p*H of Aqueous Extract

Follow the procedure specified in either **8.2.1** or **8.2.2**. If electrode systems other than those specified below are used, take similar precautions. Carry out each test at the same temperature which should be near the ambient temperature, avoiding any increase in temperature greater than 5°C.

8.2.1 *Procedure Using a Morton Cell Type Electrode System*

8.2.1.1 Standardize the meter at the temperature of the extract to be measured (*see* **7.2**).

8.2.1.2 Wash the cell several times with distilled water until the indicated *p*H no longer changes. This requires a considerable volume of distilled water.

8.2.1.3 Pour into the cell sufficient of the first extract to cover the bulb of the glass electrode. Re-stopper the flask. Allow the cell to stand for 3 min. Read the *p*H value. Drain the cell and pour in a new portion of the same extract. Re-stopper the flask. Allow the cell to stand for 1 min and read the *p*H. Repeat these operations until the indicated *p*H reaches its extreme steady value. Discard the first extract.

8.2.1.4 Without washing out the cell, pour in a sufficient quantity of the second extract to cover the bulb of the glass electrode. Read the *p*H immediately. Drain the cell and introduce a new portion of the extract. Read the *p*H value again. Repeat these operations until the indicated *p*H attains its extreme steady value.

8.2.1.5 Record this value to the nearest 0.1 unit of *p*H. Discard the extract.

NOTE — For an alkaline extract (*p*H value greater than 7), the highest steady *p*H indicated is recorded as the *p*H value of the extract and for acid extract (*p*H value less than 7) the lowest steady *p*H indicated is recorded as the *p*H value of the extract. This is referred to as the 'extreme steady value'.

8.2.1.6 Determine the *p*H of the third extract using the above procedure without rinsing the cell.

8.2.1.7 The *p*H values of the second and third extracts are recorded as duplicate determination.

8.2.2 *Procedure Using a Dipping Electrode System*

8.2.2.1 Standardize the meter at the temperature of the extract to be measured (*see* **7.2**).

8.2.2.2 Wash the electrodes until the indicated *p*H value changes by not more than 0.05 in 5 min. If this cannot be realized, replace the glass and/or reference electrodes.

8.2.2.3 Decant the first extract, with the exclusion of the textile material, into a beaker (**6.4**). Immediately immerse the electrodes to a depth of at least 1 cm and stir very gently with a glass rod until the *p*H attains its extreme steady value (*see* Note under **8.2.1.5**).

---

[1] Siemens per centimetre

8.2.2.4 Decant the second extract into a beaker. Transfer the electrodes, without washing, into the second beaker, lowering them gently to a depth of at least 1 cm and allow to stand without stirring until the *p*H attains its extreme steady value. Record this value to the nearest 0.1 unit of *p*H (*see* Note under **8.2.1.5**).

8.2.2.5 Decant the third extract in another beaker and transfer the electrodes to this beaker, again without washing. Determine the *p*H value as described above.

8.2.2.6 The *p*H values of the second and third extracts are recorded as duplicate determinations.

9 CALCULATION AND EXPRESSION OF RESULTS

9.1 Give the values obtained for the second and third extracts as 'first and second measurements'.

9.2 Calculate their mean to the nearest 0.05 unit of *p*H.

10 INDEX OF DIFFERENCE

10.1 If the value of the *p*H measured is less than 3 or greater than 9 determine the index of difference as follows:

a) Introduce 10 ml of the prepared aqueous extract into a beaker (**6.4**) and add 90 ml of distilled or deionized water (**7.1**).
b) Measure the *p*H of the solution to 0.1 unit of *p*H following the procedures specified in **8.2.1** or **8.2.2**.
c) The difference between the *p*H of the aqueous extract prepared as in **8.1** and that of the dilution to 1/10 is the index of difference.

10.2 This index of difference, which should never be greater than unity, is especially high when the textile contains strong acids or strong bases and these are not buffered by weak acids or weak bases.

11 TEST REPORT

The test report shall include the following information:

a) Reference to this method;
b) Hot method or cold method;
c) Type of electrodes used;
d) The *p*H of the distilled water used;
e) The temperature of the laboratory;
f) The results obtained, expressed in the form indicated in 9;
g) If necessary, the index of difference (*see* **10**); and
h) Any factor likely to have an effect on the results, including any resistance to wetting out of the specimen.

DETERMINATION OF VISCOSITY (OR FLUIDITY) OF SOLUTIONS OF COTTON AND REGENERATED CELLULOSIC MAN-MADE FIBRES IN CUPRAMMONIUM HYDROXIDE

(*Source* : **IS 244 : 1984)**

Viscosity of solutions of cellulose in cuprammonium hydroxide is of proven importance in some major industries. For instance, viscosity of such solutions affords a means of control of bleaching and other chemical operations to which cellulose textiles, such as cotton, linen and rayon, are put through. Manufacturers of cellulose, paper, pulp, explosives, celluloids and lacquers also use this characteristic of cellulose solutions in the control of manufacturing processes.

Viscosity of solutions of cotton and regenerated cellulose in cuprammonium hydroxide has a close correlation with the tensile strength of the fibres. For instance, very large changes at the high end of the viscosity scales are accompanied by changes in the tensile strength of the cotton and rayon fibres which are too small to be capable of direct experimental detection. The absolute viscosity of a solution of a slightly scoured cotton, containing 0.5 g of cellulose per 100 ml, is about 1 poise. But more vigorous scouring treatment may reduce this to 0.2 poise without seriously affecting the quality of the material. A further fall of viscosity from 0.2 to 0.05 poise is accompanied, however, by a loss of 20 to 30 percent in tensile strength. Changes in viscosity of the same order but at different parts of the scale have, therefore, a different technical significance; this is best brought out when the rate of flow is expressed in terms of fluidity. It has been shown that, when fluidity is plotted against the percentage loss of strength produced by chemical action on cotton, a curve is obtained which approximates more closely to a straight line than that given by other methods of expression.

While testing mixtures of cellulosic fibres, it is more appropriate to estimate the fluidity of the cotton component only and therefore, only methods for determination of the fluidity of the cotton component are given. Since the majority of the mixtures are prepared before any treatment is applied which is likely to affect the fluidity, it can be assumed that any increase in fluidity of cotton component reflects an increase in the fluidity of the other component, although these changes may not be proportional.

Three basic methods for calculating test specimen size and test results are given, the first dealing with pure fibre, the second and the third dealing with mixtures of cotton with cellulosic man-made fibres.

Difficulties in working with such cupramonium solutions are many. Firstly it is necessary to exclude air from any lengthy contact with the solutions, as oxygen causes a marked decrease in viscosity. Hence, the solutions are made in the viscometer itself. Secondly, sometime even carefully purified cotton (of consequent high viscosity) and some commercially bleached cotton yarns or cloth give turbid solutions. This is avoided if the nitrous acid content of the solutions is kept below 0.5 g/l and also if the cotton is freed from extraneous matter before being dissolved. Thirdly, solutions of cotton in cuprammonium differ from truly viscous liquids. The apparent fluidity of such solutions consequently varies with the nature and dimensions of the viscometer. This abnormality, which applies particularly to cotton of high viscosity or low fluidity (that is, normal cotton) and which rapidly becomes less accentuated as the severity of treatment of cotton is increased, may be neglected.

1 SCOPE

It prescribes a method for determination of viscosity (or fludidity) of solutions of cotton, regenerated cellulosic fibres and blends of cotton with regenerated cellulosic fibres in cuprammonium hydroxide.

2 TERMINOLOGY

For the purpose of this standard, the following definitions shall apply.

2.1 Fluidity

It is reciprocal of viscosity of the solution and is expressed in reciprocal poises.

2.1.1 *Fluidity of Cotton*

Fluidity of cuprammonium hydroxide solution containing 0.5 g of bone-dry cotton per 100 ml of solution at 20°C.

2.1.2 *Fluidity of Regenerated Cellulose*

The fluidity of cuprammonium hydroxide solution containing 2.0 g of bone-dry regenerated cellulose per 100 ml of solution at 20°C.

2.1.3 *Fluidity of Cellulose Acetate or Triacetate*

The fluidity of cuprammonium hydroxide solution containing cellulose acetate or triacetate equivalent to 2.0 g of regenerated cellulose per 100 ml of the solution at 20°C (*see* Annex A).

3 PRINCIPLE

A weighed sample of the material is dissolved in cuprammonium hydroxide solution in a viscometer. The temperature of viscometer and its contents is brought to 20°C in the thermostat. The solution is allowed to flow from the viscometer through the capillary, the time taken by meniscus to fall from one fixed mark to another is noted and then the fluidity is calculated.

4 APPARATUS

4.1 Viscometer

The viscometer shall be as shown in Fig. 1. Glass tube *A* has an internal diameter of 10 mm. The capillary *F* with an internal diameter of 0.88 mm and an external diameter of 6 mm is 25 mm long. Three marks *B*, *D* and *C* are etched around the outer surface of the tube *A* at vertical heights of 242 mm, 122 mm and 62 mm from the flat end of the capillary *F*. The upper end of the tube is closed with a rubber stopper, carrying a capillary tube *E* (the dimensions of the capillary tube *E* are not important). The lower end of rubber stopper should not protrude below the mark near the top of the viscometer. The overall lengths of the viscometer without fittings shall be 300 mm.

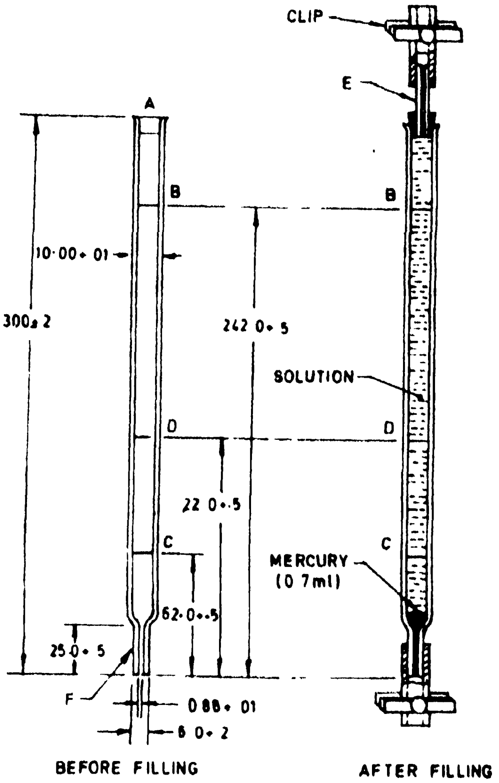
NOTE — Tolerances for various dimensions are indicated in Fig. 1

4.2 Glass Jackets

For supporting the viscometer in the thermostat during the time required to bring the temperature to 20°C and during the time the flow of solution is being measured, a glass jacket shall be provided. One typical glass jacket is shown in Fig. 2; jackets of other designs may also be used provided the viscometer remains vertical in it.

4.3 Brass Supports

With plumb line or other means of verifying that the jacket is vertical while the time of flow is being



All dimensions in millimetres

FIG. 1 VISCOMETER BEFORE AND AFTER FILLING THE SOLUTION

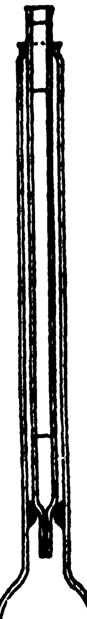


FIG. 4 VISCOMETER IN JACKET READY FOR TIME FLOW MEASUREMENT

measured. One suitable design is illustrated in Fig. 3.

4.4 **Blackened Glass Container** – for cuprammonium hydroxide solution.

4.5 A device for rotating the filled viscometer end-over-end at a speed not more than 4 rev/min.

4.6 **Glass Thermostat** – with stirrer, capable of being maintained at 20 ± 1.0°C or 20 ± 0.1°C (*see* **6.5**).

4.7 **Stop-Watch** – graduated in seconds and fifth of a second.

4.8 **Steel Rod** – approximately 1.6 mm in diameter and 300 mm long.

4.9 **Strips of Black Cloth** – to cover viscometer.

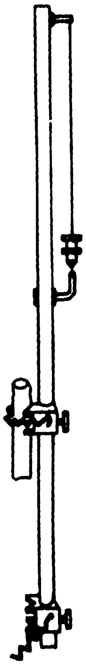


FIG. 3 BRASS SUPPORTS

5 CUPRAMMONIUM HYDROXIDE SOLUTION

5.1 The cuprammonium hydroxide solution used shall have the following composition:

Copper	15 ± 0.1g/l
Ammonia	200 ± 5 g/l
Nitrous acid	less than 0.5 g/l

5.1.1 The solution shall be prepared and tested before use as given in Annex B.

6 PROCEDURE

6.1 Remove all the non-cellulosic matter from the material under examination as given in IS 9068:1979 'Recommended methods for removal of non-fibrous matter prior to quantitative analysis of fibre mixture' (*see* Note) and dry. If a blend is to be tested, determine the composition using the appropriate method as given in IS 1564:1962 'Method for quantitative Chemical analysis of binary mixture of cellulose triacetate and certain after figures (*first revision*)', IS 1889 (Parts 1 and 2):1976 'Method for quantitative chemical analysis of binary mixture of regenerated cellulose fibre and cotton - Sodium zincate and cadoxen solvent methods', and IS 2176:1962 'Textiles- Binary mixtures of cellulose acetate and certain other fibres — Methods for quantitative chemical analysis (*first revision*)', before determining the fluidity using a fresh sample. Condition the sample in standard atmosphere at 27 ± 2°C temperature and 65 ± 2 percent relative humidity (*see also* IS 6359:1971 'Method of conditioning of textiles' given in Section B-1/1). Cut yarns or loose fibres into lengths of 2 mm such that specimen includes both warp and weft yarns.

NOTE — Some of the methods specified in IS 9068:1979 'Recommended methods for removal of non-fibrous matter prior to quantitative analysis of fibre mixture' may degrade cellulose and therefore, correct fluidity values cannot be obtained when these methods are used to remove added matter.

6.2 Mass of Specimen

Calculate the mass of the specimen of cotton or regenerated cellulose required, by the formula given in C-3.

6.2.1 *Cotton*

Assuming the moisture regain of 6.5 percent of pure or slightly modified cotton, weigh to the nearest milligram the required quantity of material as obtained in **6.1** depending on the volume of the viscometer used (*see* Annex C) to give, on bone-dry basis, 0.500 ± 0.001 percent solution. In case of mercerized cotton, weigh the required quantity of material as in **6.1** assuming moisture regain of 8.5 percent to give 0.500 ± 0.001 percent solution on bone-dry basis depending on volume of the viscometer used (*see* Annex C).

6.2.2 *Regenerated Cellulose or Cellulosic Man-made Fibres*

6.2.2.1 Weigh the required quantity of regenerated cellulose material as obtained in **6.1**, depending on volume of viscometer used (*see* Annex C) to give a 2.000 ± 0.001 percent solution on bone-dry basis assuming its moisture regain to be 11 percent. To calculate the mass of acetate or triacetate required (*see* Annex A).

6.2.3 *Mixture of Cotton with Cellulosic Man-made Fibre*

6.2.3.1 *Method 1*

Find out the concentration of the mixture required on bone-dry basis from Table 1. This concentration chosen gives simple proportionality between the fludity of the mixture and that of the cotton component.

Table 1 Concentration of Mixture Required

Cotton in Mixture[1)] Percent	Concentration 100 (Bone-Dry Mixture Required) g/ml of Cuprammonium solution
80	0.762
75	0.807
66.7	0.875
60	0 948
50	1.088
40	1.267
33.3	1.424
25	1.649

[1)] Bone-dry basis.

6.2.3.2 *Method 2*

Calculate the concentration of mixture by using the formula :

$$C_m = \frac{1}{1.5R_c + 0.5}$$

where

C_m = concentration of the bone-dry mixture, g/100 ml of the solution; and

R_c = the mass (g) of cotton per g of bone-dry mixture.

NOTE — The second method gives a concentration which equals that which would have been obtained if the components had been separate, the whole of the cotton dissolved at a concentration of 0.5 percent, the whole of the cellulosic man-made fibre being dissolved at a concentration of 2 percent, and the two solutions then mixed.

6.2.3.3 The mass M of bone-dry mixture to be taken for test is given by :

$$M = \frac{C_m V_o}{100}$$

where

C_m = concentration (g/100 ml) from Table 1 or as calculated by above formula (*see* **6.2.3.2**); and

V_o = volume (ml) of the viscometer, as determined in Annex C.

6.3 Close capillary *F* of the viscometer (*see* Fig. 1) with a short piece of pressure tubing and fill the apparatus to half of its capacity with cuprammonium solution. Run a few drops of the solution through capillary *F* to ensure that the solvent completely fills the capillary and pour 0.7 ml dry mercury into the viscometer. Add the weighed material (*see* **6.2.1**, **6.2.2** and **6.2.3**) in the viscometer and stir the solution rapidly with the steel rod. Fill the viscometer completely with cuprammonium hydroxide solution, insert the stopper so that the excess liquid overflows through the top capillary tube displacing all the air and close it immediately.

6.4 Wrap the viscometer in black cloth and fix it to rotating device. Rotate at such a speed that the mercury moves from end to end during half a revolution, till complete solution of the material is effected (*see also* Annex D).

NOTE — A maximum rate of 4 rev/min is suitable even for very viscous solutions. The agitation thus produced is sufficient to cause complete solution of the cellulose overnight.

6.5 Remove the lower clip and the rubber tube off the viscometer and suspend it in a wider tube, and place the assembly in a thermostat maintained for technical determinations, at 20 ± 1°C and for accurate determination at 20 ± 0.1°C and till temperature equilibrium is established. Now transfer the viscometer to glass jacket (*see* Fig. 2), rest it on three glass points at the lower end, and fix it vertically in the thermostat. Open the upper clip so that the solution flows out through the lower capillary. Observe the time necessary for the meniscus to fall from mark *B* to *D* and *B* to *C* respectively. The time of flow from *B* to *C* is only required to calculate the fluidity, the reading from *B* to *D* serves to detect any considerable irregularity which might be there due to partial chocking of the capillary.

NOTE — If the flow time of the solution of cellulose in cuprammonium solution is measured at room temperature instead at 20°C, the fluidity determined at that temperature may be converted to that at 20°C by the following formula:

$$F_{20} = \frac{F_t}{0.4 + 0.3t}$$

where

F_{20} = fluidity at 20°C,

F_t = fluidity determined at t°C, and

t = temperature at which the flow time is measured.

7 CALCULATIONS

7.1 Calculate the fluidity of cotton and regenerated cellulose solutions by the following formula:

$$F = \frac{C_1}{t - \frac{K}{t}}$$

where

F = fluidity in absolute units that is in reciprocal poises,

C_1 = modified constant of the viscometer (*see* **E-1.3**),

t = observed time of flow of solution from mark B to C in seconds, and

K = kinetic energy correction constant (*see* **E-1.2**),

NOTE — $\frac{K}{t}$ shall be neglected in cases where t exceeds 200 seconds

7.2 Calculate the fluidity F_m of the mixture by the formula given in **7.1**. Then calculate the fluidity F_c of cotton component by the formulae:

$$F_c = 1.4\,F_m \text{ (for Method 1 in } \mathbf{6.2.3.1}\text{)}$$

or by the formula:

$$F_c = 1.15 \times F_m - 2.2 \text{ (for Method 2 in } \mathbf{6.2.3.2}\text{)}$$

8 REPORT

The report shall state the following:

a) Fluidity of cotton,

b) Fluidity of cellulosic man-made fibre,

c) For mixtures:

   1) Composition of the blend,

   2) The fluidity of the mixture, and

   3) The fluidity of cotton.

ANNEX A

(*Clauses* 2.1.3 *and* 6.2.2.1)

CALCULATION OF THE REQUIRED MASS OF ACETATE OR TRIACETATE FIBRE

A-1 Calculate the required mass of acetate or triacetate by the following formula:

$$M = 2V_0\left(\frac{1}{100 - m} \times \frac{142{\cdot}9}{142{\cdot}9 - A}\right)$$

where

M = required mass of acetate or triacetate (mg),

V_0 = total volume of viscometer as determined in Annex C,

m = percentage of moisture (water, g/100 g of bone-dry cellulose acetate), and

A = percentage acetic acid yield of acetate or triacetate.

ANNEX B

(*Clause* 5.1.1)

PREPARATION AND TEST OF CUPRAMMONIUM SOLUTION

B-1 PREPARATION

B-1.1 Take a suitable bottle of 5 litre capacity, fitted with a cork, carrying a centrifugal stirrer and air-inlet iron tube. The other end of the iron tube is connected to the wash bottle, containing a solution of ammonia (0.88 sp gr). Place 2.6 litres of liquor ammonia (0.88 sp gr), 0.4 litre of water, 3 g of cane sugar and 180 g of precipitated reduced copper (passing through 250-micron IS Sieve) in the reaction bottle, well-lagged externally with felt, keeping the space between the bottom and the vessel filled with ice to prevent loss of ammonia and excessive formation of nitrous acid. Rotate the stirrer at a speed of approximately 400 rev/min.

B-1.2 Blow air through the wash-bottle into the reaction bottle at the rate of 10 l/h. Compare colorimetrically the solution with a standard solution containing 15 g/l of copper. When the comparison shows that the concentration of copper in the solution under preparation exceeds that of the standard (which is reached usually in about 5 or 6 hours of aeration), allow the solution to settle for 30 minutes, and syphon off the clear liquid into a stoppered bottle. Again allow the solution to settle and syphon off. Analyze the clear liquid for copper and ammonia, and adjust the concentration of copper to 15 ± 0.1 g/l of copper and to 200 ± 5 g/l of ammonia. Check the nitrous acid by analysis (*see* **B-2**) and reject the solution if the value obtained exceeds 0.5 g/l.

B-1.3 The cuprammonium solution shall be stored in a blackened bottle fitted with a tap at the bottom and connected at the top through a vessel containing alkaline pyrogallol to a glass vessel (such as a Kipp's apparatus) filled with nitrogen. Keep it preferably at temperatures below 10°C, the stability of the solution being greater at such temperatures.

B-2 ANALYSIS OF CUPRAMMONIUM SOLUTION

B-2.1 Copper Content

Boil off the ammonia from 25 ml of cuprammonium solution, acidify with nirtic acid (1:1) and boil again. Romove all nitrous acid by adding a trace of bromine and re-boiling. Cool and then add ammonia solution dropwise until blue colour is formed. Then add 10 ml glacial acetic acid followed by 3 to 5 g of potassium iodide and titrate in the usual way the liberated iodine against standard sodium thiosulphate solution. Calculate the copper content from the volume of standard sodium thiosulphate solution consumed.

[Copper content, g/l = ml of 0.1N sodium thiosulphate × 0.254 4]

B-2.2 Ammonia

Add 2 ml of cuprammonium solution to 25 ml of 2 N sulphuric acid, and titrate the excess acid with normal sodium hydroxide, using methyl red as indicator. Run a blank, using the same reagents except cuprammonium solution. Calculate the ammonia content from the difference between the readings for the blank and the solution under test.

Correct the value so obtained by subtracting from it the ammonia equivalent to copper which is 0.536 × C g/l of ammonia, C being the copper concentration (g/l).

Ammonia content, g/l = [1 N sodium hydroxide (ml) for blank − 1 N sodium hydroxide (ml) for sample × 8.5 −0.536 × C].

B-2.3 Nitrous Acid

Determine the volume of cuprammonium solution necessary to decolorize 10 ml of 0.1N potassium permanganate in the presence of excess of dilute sulphuric acid at 50°C and calculate the nitrite in the usual way.

Nitrous acid content g/l = 23.51 cuprammonium solution (ml) required to decolorize 10 ml of 0.1 N potassium permanganate.

ANNEX C

(*Clauses* 6.2, 6.2.1, 6.2.2.1 *and* 6.2.3.3)

MEASUREMENT OF THE TOTAL VOLUME ENCLOSED BY THE VISCOMETER

C-1 The total volume (ml) enclosed by the viscometer is used in calculating the mass of cellulose necessary to obtain a solution of the desired concentration.

C-2 Weigh the viscometer, first empty, and then filled with water as it would be the cuprammonium solution for use. The volume determined in this way is diminished by 0.7 ml of volume of the mercury stirrer to calculate the total volume of cuprammonium solution to be used in viscometer.

C-3 The mass of the specimen of cotton or regenerated cellulose required can be calculated by the following formula:

$$m = \frac{0{\cdot}94 \times V \times C}{100 - M}$$

where

m = mass of the specimen required,

V = volume of liquid in the dissolving tube,

M = moisture content of the specimen,

C = percentage of the solution of cotton or regenerated cellulose required, and

0.94 = density of cuprammonium hydroxide solution.

ANNEX D

(*Clause* 6.4)

PRE-TREATMENT OF FIBRES WHICH ARE DIFFICULT TO DISSOLVE

D-1 Natural cotton, very mildly scoured cotton, mineral dyed or chrome proofed cotton, cotton dyed with sulphur black and certain reactive dye require a pre-treatment for complete dissolution in cuprammonium solution.

D-1.1 Boil for 1 hour under reflux in 1 percent sodium hydroxide solution in case of grey cotton and cotton dyed with sulphur black before conditioning and testing.

D-2 Boil for 2 hours in 4 percent sodium carbonate solution in case of cotton dyed with some reactive dyes, for example those based on dichlorotriazine.

D-3 In case of mineral dyed or chrome proofed fabrics, or fabrics treated with aminoformaldehyde resins, the results are of limited value because of the hydrolytic action of the acid used on cellulose. Better fluidity value can be obtained by subtracting the fluidity value of a similarly treated control sample from that of the sample under examination. But this is only partially satisfactory because the resin or mineral dyeing may exert some protective action on the cellulose.

ANNEX E

(*Clause* 7.1)

CONSTANT *C* AND KINETIC ENERGY CORRECTION FACTOR *K*

E-1 DETERMINATION OF CONSTANT *C* OF THE VISCOMETER AND KINETIC ENERGY CORRECTION FACTOR *K*

E-1.1 Use any of the following as standard for fluidity:

a) Prepare a mixture of glycerine and water, containing approximately 65 percent of glycerine by weight and adjust the specific gravity of the solution to 1.168 1 in air at 20°C. The fluidity of this solution at 20°C is 6.83 reciprocal poises. The kinematic fluidity of this solution is approximately 8 s/cm² at 20°C.

b) Use pure phenyl ethyl alcohol (relative density 1.019 and fluidity 7.01) the kinematic fluidity of this chemical is 7.14 s/cm² at 20°C.

E-1.1.1 Fill the viscometer tube with either solution (a) or (b) and allow the liquid to acquire a temperature of 20°C. Observe the time in seconds taken for the meniscus to fall from the uper to the lower etched mark that is from the mark *B* to the mark *C* (*see* Fig. 1).

E-1.2 · If the calibrating liquid is glycerine, calculate the kinetic energy constant *K* as folows:

$$K = 0.131 \times V \times t_g$$

where

V = volume (ml) between the top and bottom timing marks *B* and *C* (*see* Fig. 1), and
t_g = time of flow in seconds of glycerine solution.

If the calibrating liquid is phenyl ethyl alcohol then:

$$K = 0.117 \times V \times t_p$$

where

V = volume (ml) between the top and bottom timing marks *B* and *C* (*see* Fig. 1), and
t_p = time of flow in seconds of phenyl ethyl alcohol.

NOTE — The value of *K* should be preferably between 400 to 500

E-1.3 Calculate the constant *C* of the viscometer by using the following formula:

$$C = 1.075 \times d \times F \times t$$

where

d = density of glycerine solution or pure phenyl ethyl alcohol,
F = fluidity in absolute units of glycerine solution or pure phenyl ethyl alcohol, and
t = time of flow in seconds.

For the determination of cuprammonium fluidity, *C* needs modification. The modified value (C_1) is given as follows:

$$C_1 = \frac{C}{d_c}$$

where

d_c = density of cuprammonium hydroxide solution.

NOTES

1 The density of the cuprammonium solvent and of dilute solutions of cellulose in cuprammonium is assumed to be 0 94 g/cm³

2 The constant *C* for the viscometer shall preferably be between 1 750 and 2 100 as determined in **A-1.3**.

METHODS FOR DETERMINATION OF CONDUCTIVITY OF AQUEOUS AND ORGANIC EXTRACTS OF TEXTILE MATERIALS

(*Source* : IS 4420 : 1967)

For textile electrical-insulating materials, the requirements of the conductivity of aqueous and organic extracts of textile materials are specified. The conductivity values of these extracts give indications of the amount of harmful water solubles and organic impurities present in the textile materials. This standard will be useful in determining the conductivity of aqueous and organic extracts of textile materials.

1 SCOPE

It prescribes method for determination of conductivity of aqueous and organic extracts of textile materials.

2 PRINCIPLE

The aqueous extract of the textile material is prepared by using low-conductivity water. An organic extract of the textile material is prepared by using trichloroethylene. The conductivity of each of the two extracts is measured separately and expressed in conventional units.

3 SAMPLING

3.1 Sampling for Fibre and Yarn

3.1.1 *Lot (Fibre or Yarn)*

The quantity of fibre or yarn from the same source shall constitute a lot. If the lot contains more than 200 kg of fibre or yarn, it shall be divided in sub-lots each weighing 200 kg or less.

3.1.2 From a sub-lot 15 increments, each approximately weighing 10 g, shall be taken from different parts so that a representative sample is obtained. All the increments thus collected shall be thoroughly mixed. This shall constitute the *test sample*.

3.2 Sampling for Fabrics

3.2.1 *Lot (Fabric)*

The quantity of fabrics manufactured essentially under uniform conditions shall constitute a *lot*.

3.2.2 The number of pieces to be selected from a lot shall be as given below. The pieces thus selected shall constitute the gross sample:

Lot Size	*Sample Size*
Up to 100	3
101 " 300	4
301 " 500	5
501 and above	7

3.2.3 From each piece in the gross sample about 25 g of fabric shall be taken out from at least two different parts. The parts shall then be cut into further smaller pieces and thoroughly mixed. The pieces thus collected shall constitute the *test sample*.

4 TEST SPECIMENS

From the test sample, draw at least 4 test specimens (2 test specimens for preparing aqueous extracts and the other two for organic extracts) each weighing about 10 g. Cut the test specimens into small pieces.

NOTE — If the sample, under analysis of loose fibre, take about 5 g of the test specimen.

5 CONDITIONING OF TEST SPECIMENS

5.1 In case of test specimens taken for preparing aqueous extract prior to test, the test specimens shall be conditioned for 24 hours to moisture equilibrium in a standard atmosphere at 65 ± 2 percent RH and 27 ± 2°C temperature.

NOTE — No conditioning is required in the case of test specimens taken for preparing organic extract.

6 QUALITY OF REAGENTS

6.1 Unless specified otherwise, pure chemicals shall be employed in test and distilled water shall be used where the use of water as reagent is intended.

NOTE — 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the test results.

7 CONDUCTIVITY OF AQUEOUS EXTRACT

7.1 Apparatus

7.1.1 *Flat Bottom Flask* – made of chemical-resistant glass and of suitable capacity with a glass stopper incorporating a stopcock.

7.1.2 *Water Cooled Condenser*

7.1.3 *Sintered Glass Crucible* – porosity 4.

7.1.4 *Conductivity Cell* – a convenient conductivity cell of known cell constant (*see* Fig. 1).

NOTE — The cell should be calibrated with N/100 potassium chloride solution which has a conductivity of 127 800 µS/m at 27°C.

7.1.5 *Conductivity Meter* – consisting of a wheatstone bridge network of resistors, fed from an alternating source of frequency not less than 1 000 c/s with a suitable device for assessing bridge balance. One arm of the network is formed by the cell containing the liquid under test (*see* Fig. 2).

7.2 Reagents – distilled water of conductivity not greater than 200 µS/m.

NOTE — The required quality of water may be obtained by passing it through mixed ion-exchange resins.

7.3 Preparation of Aqueous Extract

7.3.1 Condition the test specimens to moisture equilibrium in the standard atmosphere and weigh accurately each test specimen.

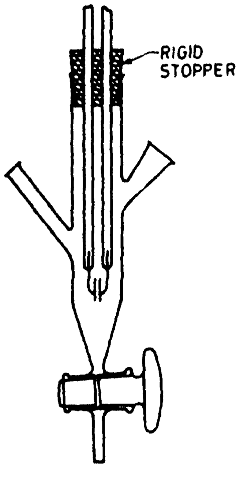
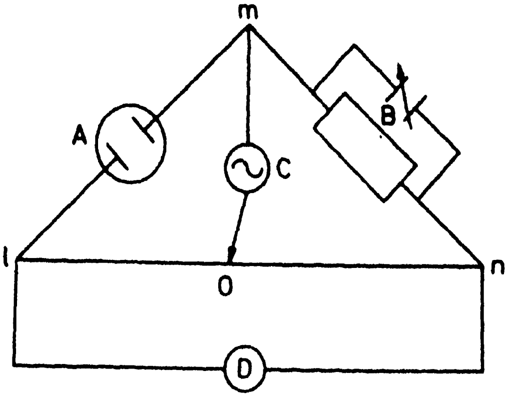


FIG. 1 APPARATUS FOR MEASURING THE ELECTRICAL CONDUCTIVITY OF LIQUIDS



A –	Electrolytic cell
B	Variable standard resistance with a variable condenser in parallel
C	Source of alternating current
D	Current detector
l, m, n	Uniform graduated wire or two variable resistance boxes

FIG. 2 CONDUCTIVITY METER

7.3.2 Put one test specimen in the flask and add sufficient amount of water to it to make liquor to material ratio of 20:1 (*see* Note). Connect the flask to the condenser and bring rapidly to boil and continue to boil the liquor gently for 60 minutes. Disconnect and remove the flask while the liquor is still boiling and close it immediately with the glass stopper fitted with the stopcock. Rapidly cool the flask to room temperature. Do not remove or open the tap until ready for filtration.

NOTE – If the test specimen is wool in any form, felt or loose fibre masses of any composition, the liquor to material ratio should be 50 : 1

7.3.3 Similarly prepare separate extracts of the remaining specimen(s).

7.4 Measurement of Conductivity

7.4.1 Remove the stopper from the flask and transfer some of the extracts to the conductivity cell (*see* Note). Wash the electrodes twice or thrice with the extract. Measure the electrical resistance with the meter. Note the temperature of the extract.

NOTE — The flask should be restoppered as soon as possible

7.4.2 Calculate the conductivity of the aqueous extract in µS/m by the formula given below:

$$\text{Conductivity of extract, micro mhos/cm at } 27^\circ\text{C} = \frac{K \times 10^8}{R[1 + 0{\cdot}02(t - 27)]}$$

where

K = cell constant (per centimetre);

R = measured resistance in ohms; and

t = temperature, in degrees celsius of extract.

NOTE — The cell constant, if not known, should be first determined by measuring the resistance of N/100 potassium chloride solution.

7.4.3 Calculate separately the conductivity of the extract(s) prepared from the remaining test specimen(s).

7.4.4 Calculate the average of the values obtained as in **7.4.2** and **7.4.3**.

8 CONDUCTIVITY OF ORGANIC EXTRACT

8.1 Apparatus

8.1.1 *Reflux Condenser*

8.1.2 *Conductivity Cell* – a convenient conductivity cell of known cell constant (*see* **7.1.4**).

8.1.3 *An Electronic Multi-Megohmmeter* – using 85-V dc, or a sensitive galvanometer and battery.

8.1.4 *Air-Oven* – capable of maintaining a temperature of 80 to 100°C.

8.2 Reagents

8.2.1 *Trichloroethylene*

NOTE — The trichloroethylene used for the extraction should be purified by stirring in about 1 percent by weight of fuller's earth and filtering through a sintered glass filter. The conductivity of the solvent when determined shall be not greater than 5×10^{-4} µS/m.

8.3 Preparation of Organic Extract

8.3.1 Take one test specimen (*see* Note 1). Heat it gently in oven for about 2 hours at a temperature of 80 to 100°C to remove any amount of absorbed water and immediately transfer it to a suitable flask. Add trichloroethylene to the flask keeping the liquor to material ratio of 10:1 (*see* Note 2). Connect the flask to the condenser. Extract the test specimen by gently boiling the trichloroethylene for about 1 hour (*see* Note 3). Stopper the flask firmly and allow it to remain overnight in the dark. Make up the loss of volume through evaporation by addition of trichloroethylene before determining the conductivity.

NOTES

1 Since the test specimen is dried before extraction, it is not necessary to condition it.

2 If the test specimen is wool in any form, felt on loose fibre masses of any composition, the liquor to material ratio should be 25:1.

3 The apparatus used should be all-glass apparatus and the joints should be made of ground glass.

8.4 Measurement of Conductivity

8.4.1 Rinse the conductivity cell several times with trichloroethylene and dry. Take the extract in conductivity cell and measure its resistance after application of current for 1 minute.

8.4.2 Calculate the conductivity of the organic extract by the formula given in **7.4.2**.

8.4.3 Similarly determine the conductivity of the organic extracts prepared from remaining test specimen(s).

8.4.4 Calculate the average of the values obtained as in **8.4.2** and **8.4.3**.

9 REPORT

9.1 Report the value obtained as in **7.4.4** and **8.4.4** as the conductivity of aqueous and organic extracts respectively.

9.1.1 Report also the liquor to material ratio used in preparing the extracts.

ESTIMATION OF MOISTURE, TOTAL SIZE OR FINISH, ASH AND FATTY MATTER IN GREY AND FINISHED COTTON TEXTILE MATERIALS

(*Source* : IS 199 : 1989)

The size used for spun textile yarns may consist of an adhesive, a lubricant, an antiseptic, or hygroscopic and weighting materials. The adhesive is generally starch or soluble starch, but certain other carbohydrates, for example, locust-bean gum, may be used alone or in mixtures with starch. The filling applied to fabric in finishing may contain starch or dextrins with or without lubricant, and sometimes substantial proportion of weighting materials, such as, china clay. The procedure described for estimation of starch is for use where test specimens of about 2 g are available; weighting materials, if present, are mainly removed along with the starch; the residual filling may be determined by ashing the desized specimen and, provided that the amount of residual mineral matter is small, changes in its mass produced during ashing may be neglected. Unsized grey cotton loose mass in desizing process and correction factor for the loss, has to be applied to the mass of the residual. The correction can be determined if a specimen of the corresponding unsized yarn is available. In the absence of such a specimen, the values for the correction factor are assumed.

The oils, fats and waxes present in cotton may be derived either from the cotton itself, or from sizing and finishing compositions added during manufacture. With some exceptions, these materials are removed by extraction with suitable solvent. Dichloromethane (methylene chloride) has been found as suitable solvent for grey, scoured and bleached cotton if the extraction time does not exceed six hours, but it is unsuitable for dyed or printed materials containing vat or azoic dyes or colourants for which the use of light petroleum (boiling range 40 to 60°C) is recommended. The amount of natural fat or wax extracted from cotton materials by light petroleum is smaller than that extracted by dichloromethane. The method prescribed does not purport to remove natural fats and waxes completely. It gives a result that may be low by about 0.2 g per 100 g of cotton or raw cotton, and low by less than this amount on partly purified cotton but which is nevertheless, reproducible and serves to characterize the cotton sufficiently for practical purposes.

1 SCOPE

1.1 It prescribes methods for estimation of (a) moisture, (b) total size or finish, (c) ash, and (d) fatty matter in grey and finished cotton textile materials.

1.2 The method prescribed for estimation of starch is not applicable in cases where the starch has been insolubilized as in formaldehyde-containing finishes and is not intended for use in determining small amounts of residual starch and fatty materials. The method prescribed for determination of fatty matter is not applicable to textile materials containing oxidized unsaturated oils, waterproofing or softening preparations derived from cetylpyridinium halides, rot-proofing agents, synthetic resins and other substances that would interfere.

2 SAMPLING

2.1 Samples from the lot for testing shall be selected so as to be representative of the lot.

2.2 Samples drawn in accordance with the procedure laid down in the material specification or as agreed to between the buyer and the seller shall be held to be representative of the lot.

3 QUALITY OF REAGENTS

3.1 Unless specified otherwise, pure chemicals shall be employed in the tests and distilled water shall be used where the use of water as a reagent in intended.

NOTE — 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the results of analysis

4 ESTIMATION OF MOISTURE

4.1 Apparatus

4.1.1 *Drying Oven*, capable of maintaining a temperature of 105 ± 3°C.

4.1.2 *Weighing Balance*

4.2 Procedure

From the sample under test (*see* **2**) draw at least 2 test specimens each weighing approximately 3 g.

4.2.1 Take one test specimen drawn as in **4.2** and weigh it accurately in a clean and dry tared weighing bottle. Place the weighing bottle containing the test specimen in the drying oven and dry the specimen at 105 ± 3°C to constant mass (*see* Note) and determine the oven-dry mass of the test specimen.

NOTE — The mass may usually be regarded as constant if the loss between two successive weighing, taken at an interval of 20 minutes, does not exceed by 0.1 percent of the first of the two values.

4.2.2 Similarly test the other test specimen(s).

4.3 Calculations

Calculate the percentage of moisture content in the test specimen by the following formula:

$$\text{Moisture content, percent} = \frac{(a-b)}{a} \times 100$$

where

a = original mass in g of the test specimen, and
b = oven-dry mass in g of the test specimen.

4.3.1 Determine the mean of all values, obtained in **4.3** and express it as moisture content of the material in the lot.

4.3.2 Corrected invoice mass of cotton textile materials may be calculated by the following formula:

$$L_1 = \frac{L(b \times 1{\cdot}085)}{a}$$

where

L_1 = corrected invoice mass in g of the lot,
L = original mass in g of the lot,
b = oven-dry mass in g of the test specimen, and
a = original mass in g of the test specimen.

5 ESTIMATION OF TOTAL SIZE OR FINISH

5.1 Apparatus

5.1.1 *Soxhlet Extractor*

5.1.2 *Drying Oven*, capable of maintaining a temperature of 105 ± 3°C.

5.1.3 *Sintered Disc Filter Crucibles*, of at least 60 ml capacity, fitted with ground glass stopper or other suitable cover.

5.1.4 *Suitable Ignition Crucibles and Covers*

5.1.5 *Muffle Furnace*, or other equipment for heating crucibles to a temperature of about 750°C.

5.2 Reagents

5.2.1 *Dichloromethane (Methylene Chloride)*, redistilled.

5.2.2 *Diastase or Other Suitable Desizing Enzyme*

5.2.3 *Sodium Chloride*

5.2.4 *Soap-Soda Solution*

It shall contain 20 g of soap and 10 g of anhydrous sodium carbonate per litre. The soap shall contain not more than 5 percent moisture and shall comply with the following composition on dry mass basis:

Free alkali (as Na_2Co_3), *Max*	0.3	percent
Free alkali (as NaOH), *Max*	0.1	percent
Combined fatty acids (as sodium salt), *Min*	85	percent
Titre of mixed fatty acids prepared from the soap, *Max*	30°C	
Iodine value of fatty acids, *Max*	50	

5.3 Procedure

From the sample under test (*see* **2**), draw at least 2 test specimens each weighing approximately 2 g.

5.3.1 If the sample under test is yarn, cut each test specimen, into pieces of 15 cm long, from into separate bundles and tie each bundle loosely round the middle.

5.3.2 If the sample under test is fabric, trim each test specimen parallel to the directions of warp and weft and pull out 5 threads all round to form a fringe.

5.3.3 Determine the moisture content of the sample by the method prescribed in **4**, using separate test specimens. Weigh accurately one test specimen in a tared crucible drawn as in **5.3** and calculate its oven-dry mass. Place the crucible with specimen in a Soxhlet apparatus, with its rim above the level of the siphon and extract it in a Soxhlet extractor for one hour with dichloromethane adjusting the rate of boiling to at least six hot extractions per hour.

5.3.4 Remove the crucible from the extractor and allow the solvent to evaporate. Attach the crucible to a Buchner flask and wash the extracted specimen by drawing about 100 ml of water through it. Drain and remove the crucible and transfer the contents to a flask of 150 ml capacity.

5.3.5 Treat the extracted specimen in the manner prescribed in **5.3.5.1**, **5.3.5.2**, or **5.3.5.3** depending on the type of the ingredients used in the size or finish.

5.3.5.1 In case it is known that the material is sized or finished with a mixing containing starch but not tamarind kernel powder, add to the flask 50 ml of bacterial diastase solution containing 5 g/l of active diastase, 10 g/l sodium chloride and 0.1 percent (*m/m*) of a non-ionic wetting agent at 70°C and at a *p*H of 6.5 to 7.5 (*see* Note). Maintain this temperature for 30 min and shake the contents of the flask by any convenient means continuously or at intervals of 5 min during this time. Decant the solution through the filter crucible, add a fresh portion of bacterial diastase solution at 70°C and at a *p*H of 6.5 to 7.5 to the flask and repeat the desizing treatment. Take precaution to ensure that the temperature in any part of the solution does not exced 70°C or the limiting temperature specified by the manufacturer of enzyme. After decanting the second portion of the solution, add water to the flask and boil for 5 min. Finally transfer the desized material to the crucible, drain and wash with three successive 100 ml portions of hot water while stirring the contents with a glass rod, and drain with suction after each wash. If the washings are opalescent with mineral filling, continue washing until they are clear.

NOTE — The temperature and *p*H given for the desizing solution are the optimum for bacterial diastase. If any other type of desizing enzyme is used, then the temperature and *p*H should be modified to that recommended by the supplier. As many enzymatic desizing agents slowly deteriorate in storage, care should be taken to see that the sample of desizing agent, at the time of test, has still satisfactory desizing efficiency.

5.3.5.2 In case it is known that the material is sized or finished with a mixing containing tamarind kernel powder but not starch, boil the specimen in the soap-soda solution (weighing 20 time the mass of the specimen) for 45 minutes. Wash it thoroughly first in hot water and then in cold water.

5.3.5.3 In case it is known that the material is sized or finished with a mixing containing both starch and tamarind kernel powder or in case the ingredients used in the size or finish are not known desize the specimen as prescribed in **5.3.5.1** and treat it further as prescribed in **5.3.5.2**.

5.3.6 Dry the specimen treated as above (*see* **5.3.3** to **5.3.5**) in the drying-oven at 105 ± 3°C to constant mass (*see* Note under **4.2.1**) accurately.

5.3.7 *Residual Mineral Filling*

If the sample orginally contained a substantial amount of insoluble mineral filling, for example, china clay, transfer the desized specimen to an ignition crucible, previously ignited with its lid at 750°C (*see* Note 3 under **6.2.1**), cooled and its mass determined. Place the open crucible at the front of the muffle furnace and burn off the fibre while manipulating the crucible lid to prevent the fibre from inflaming. Move the crucible to the interior of the furnace, replace the lid, and continue the combustion at 750°C until no carbonaceous residue remains. Cool and determine the mass of the crucible and its content and calculate the mass of ash. Correct the mass of the desized specimen by subtracting the mass of the ash.

5.3.8 Similarly repeat the test with other test specimens.

5.4 Calculations

Calculate the percentage of total dry size or finish expressed on the oven-dry mass of the unsized material by the following formula:

$$X = \frac{a - kb}{kb} \times 100$$

where

X = total size or finish, percent by mass;

a = oven-dry mass (calculated) in g of the test specimen containing the size or finish;

k = $\frac{c}{d}$, that is, the correction factor determined experimentally (on unsized or blanks) for adjusting the value of b, due to loss of natural constituents sustained by the test specimen during treatment as prescribed in **5.3.3** and **5.3.4**;

b = oven-dry mass in g of the test specimen determined as in **5.3.6** or **5.3.7**, if necessary;

c = oven-dry mass in g of unsized or unfinished blanks; and

d = oven-dry mass in g of blank after treatment as prescribed in **5.3.3** to **5.3.7**

NOTE — Normally k cannot be determined experimentally as a comparable unsized or unfinished control blank is usually not available, particularly so in the case of fabric. In the absence of a control blank, k shall be taken as equal to 1.05 in the case of grey yarn and fabric; and equal to 1.00 in the case of scoured bleached, dyed, mercerized and printed material. The prescribed values of k for unsized grey cotton material may vary from actual value, particularly if Indian cottons are involved. Therefore, some slight inaccuracy may be expected when the prescribed values are used.

5.4.1 Determine the mean of all values as obtained in **5.4**.

5.4.2 Total size or finish of cotton textile material expressed as a percentage of:

a) original mass of the material,
b) conditioned mass of the material, and
c) corrected invoice mass of the material, may be calculated by the following formula:

$$X_1=\frac{a-kb}{a_1}\times 100$$

$$X_2=\frac{a-kb}{a_2}\times 100$$

$$X_3=\frac{a-kb}{kb\times 1\cdot 085}\times 100$$

where

X_1 = total size or finish as a percentage by mass of the original mass of the material,
X_2 = total size or finish as a percentage by mass of the conditioned mass of the material,
X_3 = total size or finish as a percentage by mass of the corrected invoice mass of the material,
a = oven-dry mass (calculated) of the test specimen containing the size or finish,
k = correction factor for b (*see* **5.4**),
b = oven-dry mass of the test specimen determined as in **5.3.5**,
a_1 = original mass in g of the test specimen, and
a_2 = conditioned mass in g of the test specimen.

6 ESTIMATION OF ASH

6.1 Apparatus

6.1.1 *Silica or Porcelain Crucible*, of about 40 ml capacity.

6.1.2 *Muffle Furnace*, capable of being heated to 750°C.

6.1.3 *Drying Oven*, controlled at 105 ± 3°C.

6.1.4 *Weighing Bottle*, of suitable size and shape to contain the crucible.

6.1.5 *Desiccator* (*vacuum Type*), containing anhydrous calcium chloride.

6.1.6 *Pastille Press*, One, suitable for making pastilles of 15 mm diameter.

6.2 Procedure

6.2.1 Compress a suitable mass of the material (*see* Note 1) into pellets from 0.5 to 1.0 g each and heat in an open, tared, weighing bottle at 105 ± 3°C overnight (*see* Note 2). Place the stopper in the bottle and after cooling in a desiccator, determine the mass of the bottle and its contents. Transfer the pellets to the crucible which has previously been ignited, cooled in desiccator and its mass accurately determined in the weighing bottle. Burn the pellets cautiously at the front of the open furnace, taking care to avoid draughts and when the material has reached the glowing stage, move the crucible towards the rear of the furnace, close the front door, and complete ashing at about 750°C (*see* Note 3). Transfer the dish after it has been allowed to cool in the desiccator, to the weighing bottle and finally determine its mass (*see* Note 3).

NOTES

1 The mass of material used is governed by the anticipated ash, for example, for grey cottons a 5 g specimen is generally used; for a well-scoured or bleached cotton material, a 10 g specimen is needed to give an amount of ash that can be dertermined with reasonable accuracy.

2 For many purposes, the initial drying of the specimen may be neglected and an average figure assumed for the moisture content of the fibre.

3 Certain metals can be lost under these conditions of heating. Mercury is lost readily and zinc is lost above 450°C. Temperatures in excess of general ashing temperature may occur locally in large specimens and the general ashing temperature in such cases may have to be considerably reduced to avoid loss of certain metals Lead is also lost under the specified conditions of heating unless sulphate ion is present.

4 Considerable loss in ash may occur due to draught. It is particularly necessary to exercise caution in opening the desiccator in which the ash has been cooled since a partial vacuum is created during cooling The safest prodcedure is to press a piece of filter paper against the outlet whilst cautiously opening the tap.

5 Silica and porcelain crucibles become etched during heating and cooling cycles over a prolonged period and it is recommended that crucibles should be renewed fairly frequently.

6.2.2 Similarly repeat the test with at least one more test specimen.

6.3 Calculation

Calculate the percentage of ash by the following formula:

$$\text{Ash content, percent} = \frac{a}{b} \times 100$$

where

a = mass in g of the residue (ash), and

b = oven-dry mass (calculated) in g of the test specimen.

6.3.1 Determine the mean of all values as obtained in **6.3**.

7 ESTIMATION OF FATTY MATTER

7.1 Apparatus

7.1.1 *Soxhlet Extractors*, of capacity 200 to 250 ml.

7.1.2 *Flat-Bottomed Extraction Flasks*, of capacity 250 to 300 ml.

7.1.3 *Double-Surface Reflux Condensors*

7.1.4 *Suitable Solvent Removal Apparatus*, all glass wire shall be fitted with interchangable ground glass joints.

7.1.5 *Drying Oven*, controlled at 105 ± 3°C.

7.1.6 *Thimbles*, previously extracted with the solvent.

7.2 Reagents

7.2.1 *Dichloromethane* (*Methylene Chloride*), redistilled.

7.2.2 *Light Petroleum*, redistilled, boiling range 40 to 60°C.

7.3 Procedure

7.3.1 From the sample under test, draw at least two test specimens each weighing about 5 g.

7.3.2 Take one test specimen drawn as in **7.3.1** and weigh it accurately in a clean dry, tared weighing bottle. Place the weighing bottle containing the test specimen in the drying oven maintained at 105 ± 3°C and dry the specimen to constant mass (*see* Note under **4.2.1**) and note the mass to an accuracy of 0.05g.

7.3.3 If the material contains size or finish based on starch in which oil, fat or wax has been incorporated, treat the specimen in 0.4 N hydrochloric acid for 30 minutes under reflux at the boil, rinse thoroughly in water and dry at a temperature not exceeding 55°C. Place the specimen in a thimble in a Soxhlet extractor. Dry an extraction-flask at 95 to 100°C, cool in a desiccator and determing its mass. Assemble the apparatus and pour the solvent (*see* Note) slowly through the condenser until the siphon operates. Add a further 10 to 20 ml of solvent. Heat the flask on a water-bath or electric hot plate so that the solvent siphons at least six times per hour for three hours, keeping the volume of solvent fairly constant by adding enougth of it to make up for any loss due to evaporation.

NOTE — The choice of solvent should be as agreed to between the buyer and the seller.

7.3.4 Disconnect the apparatus and remove the bulk of the solvent by means of the removal apparatus. Evaporate the extract carefully to dryness in the flask on a steam bath, removing the last traces of solvent by means of a jet of clean air. Further dry the contents in the drying oven at 105 ± 3°C to constant mass (*see* Note under **4.2.1**), cool in a desiccator and determine the mass of the specimen to an accuracy of 0.05 g.

7.3.5 Similarly repeat the test with the remaining test specimen(s).

7.4 Calculation

Calculate the percentage of fatty matter by the following formula:

$$\text{Fatty matter, percent, on dry mass basis} = \frac{b}{a} \times 100$$

where

b = mass in g of the extract (*see* **7.3.4**), and

a = oven-dry mass in g of the test specimen (*see* **7.3.2**).

7.4.1 Determine the mean of all values as obtained in **7.4**.

8 REPORT

The report shall include the following information:

a) Average moisture content, percent;
b) Average size or finish, percent.
c) Average ash content, percent;
d) Average fatty matter, percent; and
e) Solvent used in the extraction of fatty matter.

DETERMINATION OF SOIL RESISTANCE AND SOIL RELEASE EFFICIENCY OF FINISHED TEXTILE FABRICS

(*Source* : **IS 11813 : 1986**)

The soiling of textile fabrics is one of the most difficult problems associated with their use. Cotton and cellulosic fabrics do not pose a severe problem of soiling because of their high moisture regain. Nevertheless, the resin finished cellusosic fabrics and fabrics rich in synthetic fibres pose a severe problem of soiling during their usage. The soiling of fabrics is due to: (a) interfacial attraction or Vander Wall forces, (b) electrostatic attraction, (c) mechanical forces, and (d) hydrophobicity of the fibres.

The soil is mainly of two types, namely, dry or particulate soil and oily or greasy soil. The former which includes particles of dust, sand, earth, soot, metallic oxides and carbon with tarry substances may be hydrophilic (metallic oxides) or hydrophobic (carbon) in nature. The latter includes glycerides, long chain fatty acids and alcohols, lubricating oil, etc, which are mostly hydrophobic.

This method is for determination of soil resistance and soil release efficiency of finished textile fabrics and garments for both types of soil as mentioned above. In normal use, both types of soils may be present on the fabric. It is, therefore, advisable to test the fabric for both types of soil before use.

For evluation of soil resistance and soil release efficiency of the fabric, synthetic soils are used for soiling purpose. Ferric oxide and carbon black in fine powder form are employed as particulate soil whereas used lubricating oil SAE 40 is employed as oily soil. In the absence of a standard used lubricating oil, it is recommended to use a standard oil and add to it 10 percent of carbon black particles of standard mesh size of 20 to 25 nm.

The latter is hydrocarbon based and is similar to natural soiling encountered in actual usage as it contains carbon particles dispersed in oil phase. The properties of these soils are given in Table 1 (*see* 5.2).

1 SCOPE

1.1 It prescribes a method for determining soil resistance and soil release efficiency of finished textile fabrics and garments.

1.2 The method can also be used to assess the relative washing efficiency of surfactant auxiliaries.

2 PRINCIPLE

A specimen of the fabric under test is soiled with synthetic soil, washed under prescribed conditions and dried. Simultaneously, a control specimen and a control washed specimen are taken from the fabric under test. The soil resistance and soil release efficiency of the fabric is determined as described in 7.3.

3 SAMPLING

3.1 Lot

The quantity of one definite type and quality of a fabric or garment delivered to a buyer against one despatch note shall constitute a lot.

3.2 Sample shall be drawn so as to be representative of the lot.

3.3 Sample drawn in compliance with the material specifications or as agreed to between the buyer and the seller to evaluate soil resistance and soil release efficiency of the textile fabric in the lot shall be held to be representative of the lot.

4 APPARATUS

4.1 An accelerotor consisting of a rotor capable of rotating at 1 600 rpm. The rotor consists of motor to which a shaft is attached. The shaft carries two arms at the end which are enclosed in a circular chamber having a door. A hole is provided on the upper part of this chamber for pouring particulate soil.

NOTE — Accelerotor type AB 7 of Atlas Electric Device Co, Chicago, USA may be used without the liner. Other similar instruments capable of producing consistent results may also be used. This type of instrument can be fabricated with little efforts.

4.2 A gas tight micrometer syringe to apply oily soil on the fabric with an accuracy of 0.01 ml.

4.3 A launderometer for washing the specimen.

4.4 A drying oven in which temperature can be maintained at 70 ± 5°C.

4.5 A spectrophotometer used in colour matching systems.

4.6 A white plate coated with barium sulphate.

5 QUALITY OF REAGENTS

5.1 Unless otherwise specified, pure reagents shall be employed in the tests. Distilled water where the use of water as a reagent is intended, shall be used.

NOTE — 'Pure chemicals' shall mean the chemicals which do not contain impurities that affect the experimental results.

5.2 Soil

Ferric oxide or carbon black in fine powder form is used as particulate soil, whereas lubricating oil SAE 40 conforming to IS 496 : 1982 'Specification for automotive internal combustion engine lubricating oils' or IS 10356 : 1982 'Specification for automotive internal combustion engine lubricating oils from base stocks of mixed crudes' after it turns black during usage, or any other equivalent oil is employed as oily soil. The details of dry particulate and oily soils are given in Table 1.

5.3 A non-ionic detergent based on ethylene oxide condensate for washing, conforming to Type 2 of IS 9458 : 1980 'Specification for synthetic detergents for washing woollen and other delicate fabrics'.

NOTE — The detergent selected should be capable of working at 50 ± 5°C satisfactorily.

5.4 Carboxymethyl Cellulose (CMC)

Sodium salt to prevent redeposition of soil during washing.

5.4.1 CMC normally used in sizing and printing of textiles is suitable.

6 PREPARATION OF SPECIMEN

6.1 From the sample as selected in **3.2**, cut twelve specimens of 10 cm × 10 cm size.

6.2 Take four of the twelve specimens as obtained in **6.1** and mark them as control specimens. Mark the other eight specimens as test specimens.

7 PROCEDURE

7.1 Soiling of the Specimens

7.1.1 *Method for Particulate Soil*

7.1.1.1 Take four test specimens (*see* **6.2**) and weigh each of them nearest to one mg.

7.1.1.2 Weigh the particulate soil exactly 5 percent of the bone dry mass of the two test specimens.

7.1.1.3 Keep the arms of the accelerotor in horizontal position and place the two test specimens one on each arm.

7.1.1.4 Secure the door of the chamber tightly and pour the calculated and weighed amount of soil (*see* **7.1.1.2**) inside the chamber through a hole situated in the upper part of the chamber.

7.1.1.5 Switch on the rotor and maintain its speed at 1 600 rpm for one minute. This simulates deposition of

Table 1 Properties of Soils to be Used
(*Clauses* 5.2 *and* 7.1.2.2)

Sl No.	Property	Used Lubricating Oil	Ferric Oxide	Carbon Black
i)	Physical nature	Liquid	Powder	Powder
ii)	Chemical nature	Hydrophobic	Hydrophilic	Hydrophobic
iii)	Colour	Black	Red	Black
iv)	Density (g/cm^3)	0.91 ± 0.01	–	
v)	Viscosity (cps)	275	–	–
vi)	Particle size (microns)	–	0.3 to 1.6	2 to 4

airborne soil on the test specimens. Take out the uniformly soiled test specimens and keep them aside for spectrophotometric measurement and washing.

7.1.1.6 Repeat the procedure from **7.1.1.2** to **7.1.1.5** for remaining two test specimens as obtained in **7.1.1.1** (*see* Note 1 under **7.1.2.6**).

7.1.2 *Method for Oily Soil*

7.1.2.1 Take the other two test specimens (*see* **6.2**) and weigh each of them nearest to one mg.

7.1.2.2 Calculate the amount of 'used lubricating oil' (*see* **5.2**) 45 percent on the mass of the test specimens and convert it into ml taking into account the density of the oil (*see* Table 1).

7.1.2.3 Pour exactly half of the calculated amount on each test specimen with the help of a gas micrometer syringe and place them on each arm of the rotor of the accelerotor.

7.1.2.4 Secure tightly the door of the chamber, switch on the motor and maintain its speed at 1 600 rpm for three minutes. Take out the uniformly soiled test specimens and keep them aside for spectrophotometric measurement and washing.

7.1.2.5 The uniformly soiled test specimens shall not have maximum reflectance variation of more than ± 5 percent. In case, the test specimens as soiled in **7.1.2.4** do not meet this requirement, two fresh test specimens shall be cut from the sample and treated as given in **7.1.2.1** to **7.1.2.4** till they meet the requirement given in **7.1.2.5**.

7.1.2.6 Repeat the procedure given in **7.1.2.1** to **7.1.2.5** for the remaining two test specimens (*see* **6.2**).

NOTES

1 The chamber should be cleaned in between two successive soiling operations.

2 Alternatively the sample is fixed on an embroidery ring and secured tight. The exact amount of soil is poured in the middle of the sample and allowed to wick for 16 to 20 hours. Each sample is processed similarly.

7.2 Washing

7.2.1 Wash two of the control specimens (*see* **6.2**) and four soiled test specimens, two each as obtained in **7.1.1.5** and **7.1.2.5** in a launderometer in separate baths each containing 3.5 g/l of a non-ionic detergent (*see* **5.2**) and 1g/1 carboxymethyl cellulose (*see* **5.4**) at 50°C for 30 minutes at a liquor ratio of 1 : 50.

NOTE — The specimens should be fully exposed to the wash liquor from both the sides.

7.2.2 Rinse the washed specimens with tap water for 10 minutes and again rinse them with distilled water.

7.2.3 Dry the washed specimens in an electric oven at 70 ± 5°C for 20 minutes.

7.3 Assessment of Soil on Fabrics

7.3.1 Calibrate the spectrophotometer against a standard white plate of barium sulphate as per the method given in Annex A.

7.3.2 Find out the minimum percent reflectance on the spectrophotometer and note down the corresponding wave length for two specimens soiled with particulate soil — ferric oxide as obtained in **7.1.1.6** and that of two particulate - soiled and washed specimens at the same wavelength as above, as obtained in **7.2.3** at four different places on each side for each specimen and calculate the average value from these sixteen readings – eight for each specimen for both the sets, soiled and soiled-washed separately. Repeat the exercise for one control and one control-washed specimen at the same wavelength as above and calculate the average of eight readings for each separately.

7.3.3 Find out percent reflectance on a spectrophotometer at 450 and 650 nm for the two specimens soiled with oily soil as obtained in **7.1.2.6** at four different places on each side for each specimen and calculate the average of 32 readings. Perform similar exercise on two oily soiled and washed specimens as obtained in **7.2.3**, and one control and one control-washed specimen and calculate the average reflectance separately for oily soiled, soiled-washed, control and control-washed specimens.

7.3.4 Calculate the Kubelka-Munk ratio $\left(\frac{K}{S}\right)$ for soiled, soiled-washed, control and control-washed specimens separately as obtained in **7.3.2** and **7.3.3** for both types of soil using the following formula:

$$\frac{K}{S} = \frac{(1-R)^2}{2R}$$

where

K = Absorption coefficient,

S = Scattering coefficient, and

R = Average percent reflectance as measured in **7.3.2** or **7.3.3**.

7.3.5 *Determination of Soil Resistance*

7.3.5.0 This can be done correctly only in case of particulate soil.

7.3.5.1 Find out $\frac{K}{S}$ value for the soiled and control sample and determine the soil resistance as follows:

Soil Resistance, $s = \left(\frac{K}{S}\right)_P - \left(\frac{K}{S}\right)_C$

$\left(\frac{K}{S}\right)_P$ = Kubelka-Munk ratio for particulate soiled sample, and

$\left(\frac{K}{S}\right)_C$ = Kubelka-Munk ratio for control sample.

7.3.6 *Determination of Soil Release Efficiency*

7.3.6.1 Calculate the degree of soil retained on the fabric specimen separately for particulate soil and oily soil using the formula:

$$D_{SR} = \frac{\left(\frac{K}{S}\right)_W - \left(\frac{K}{S}\right)_U}{\left(\frac{K}{S}\right)_S - \left(\frac{K}{S}\right)_C}$$

where

D_{SR} = Degree of soil retained on the fabric specimen,

$\left(\frac{K}{S}\right)_W$ = Kubelka-Munk ratio for soiled-washed specimen,

$\left(\frac{K}{S}\right)_U$ = Kubelka-Munk ratio for control-washed specimen,

$\left(\frac{K}{S}\right)_S$ = Kubelka-Munk ratio for soiled unwashed specimen, and

$\left(\frac{K}{S}\right)_C$ = Kubelka-Munk ratio for control unwashed specimen.

7.3.6.2 Calculate the percent soil retained on the fabric separately for both types of soil by multiplying D_{SR} by 100, that is, percent soil retained = $D_{SR} \times 100$.

7.3.6.3 Calculate the percent soil removed during washing for both types of soil by the formula.

Percent soil removed during washing or soil release efficiency = $100 (1 - D_{SR})$ where D_{SR} is the value obtained in **7.3.6.1**.

8 REPORT

The report shall include the following information:

a) Nature, type and constructional details of fabric being tested;

b) Nature, and type of finish given to the fabric;

c) Percent soil retained on the fabric after washing separately for the particulate and the oily soil;

d) Soil release efficiency separately for the particulate and the oily soil; and

e) Soil resistance of the fabric or garment for particulate soil only.

ANNEX A

(*Clause* 7.3.1)

METHOD FOR CALIBRATION OF SPECTROPHOTOMETER

A-1 Keep the spectrophotometer in an air-conditioned chamber at 27 ± 2 °C.

A-2 Switch on the instrument about 90 minutes before use.

A-3 Set the arbitrary value, given with the instrument, on the panel.

A-4 Keep the white plate coated with barium sulphate below the sensor and calibrate the instrument at an interval of 10 nm. Set the reading to 100 ± 0.5 on the digital panel, each time.

A-5 Calibrate the instrument for the full range of wavelength from 380 to 760 nm. The instrument is now ready for recording the measurements.

DETERMINATION OF FLAMMABILITY AND FLAME RESISTANCE OF TEXTILE FABRICS

(*Source* IS 11871 : 1986)

The flammability is one of the important properties of textile materials, besides characteristics like combustion, thermal degradation, smouldering, after glow, smoke and toxicity With the increasing awareness of fire hazards and promulgation of rules and regulations by several advanced countries, the development of flammability standard needs no emphasis

1 SCOPE

It prescribes two methods for determining the flammability and flame resistance of textile fabrics It applies to all types of textile fabrics, clothing and garments whether woven, knitted, bonded, laminated or surface coated

2 APPLICATION

2.1 Method A based on vertical flame test is recommended for evaluating flame resistance of all types of textile fabrics Method B based on 45° inclination flame test covers the evaluation of flammability of textile clothing and textiles intended to be used in clothing

2.1.1 The methods described are not applicable to rugs and carpets and for interior fabrics used for passenger vehicles

3 DEFINITIONS

For the purpose of this standard, the following definitions shall apply

3.1 Flammability

The characteristics of a material which pertain to its relative ease of ignition and relative ability to sustain combustion

3.2 Flame

As related to textile flammability, a hot, luminous zone of gas or matter in gaseous suspension or both, that is, undergoing combustion, which is relatively constant in size and shape and which produces a relatively low heat flux

3.3 Ignition

Flaming of the specimen for a period of 1 s or more after the removal of the igniting source

3.4 Flashing

The sudden transition of a state of total surface involvement in a fire of combustible material within a compartment

3.5 Flame-Retardant

A chemical used to impart flame resistance

3.6 Flame-Retardant Finish

A process for incorporating or adding flame retardant(s) to a material or product

3.7 Flame-Resistance

The property of a material whereby flaming combustion is prevented, terminated, or inhibited following application of a flaming or non-flaming source of ignition, with or without subsequent removal of the ignition source The degree of flame resistance exhibited by a specific material during testing may vary with different test conditions

3.8 Flame Resistant

The material having flame resistance

NOTE — Flame resistant is a mandatory description for a product that meets established conformance standard when the product is tested by a specific method Where no conformance standard exists flame resistant is a relative term and is used to compare one material with another

3.9 Flame-Proof Fabric

A fabric which does not propagate flame, that is, any flame goes out quickly when the igniting flame is withdrawn

3.10 Glow

Visible flameless combustion of the solid phase of a material

3.11 After-Glow

Persistence of glow in a material under specified test conditions, after the removal of an external ignition source or after the cessation (natural or induced) of flaming of the material.

3.12 Duration of After-Glow (After-Glow Time)

The time for which a material continues to glow, under specified test conditions, after cessation of flaming, or after removal of the ignition source.

3.13 Extent of After-Glow

The area of specimen in which the after-glow spreads beyong the area damaged by flaming.

3.14 Duration of Flame (After-Flame Time)

The length of time for which a material continues to flame, under specified test conditions, after the ignition source has been removed.

3.15 Char Length

The distance from the edge of the specimen exposed to the flame under specified test conditions, to the upper edge of the charred section of the specimen, expressed in metric units.

3.16 Raised Fabric

A fabric with raised, brushed or napped surface or with cut or uncut pile.

3.17 Unraised Fabric or a Fabric of Plain Surface

A fabric having a surface significantly free from raised fibres, nap or pile.

4 PRETREATMENT OF FABRIC

4.1 In order to determine the durability of a flame-retardant in case of treated fabrics, the specimens shall be subjected to leaching, washing, and/or dry cleaning treatments as described in Annex A depending upon the end use.

4.1.1 The selection of leaching, and/or dry cleaning treatments, the number of such treatments and their sequence shall be as agreed to between the buyer and the seller or as specified in the relevant material specification.

4.1.2 In reporting the results of a test it shall be clearly stated whether the fabric was tested:

a) without preliminary dry cleaning, leaching and washing procedures, or
b) after specified dry cleaning procedures, or
c) after specified leaching and/or washing procedures.

5 SAMPLING

Sample for test shall be selected so as to be representative of the lot. Sample drawn in accordance with the material specification or as agreed to between the buyer and the seller shall be held to be representative of the lot.

6 METHOD A: VERTICAL FLAME TEST

6.1 Principle

A conditioned strip of fabric is suspended vertically and ignited at the base by flame impinging on both sides in standard manner. After igniting the specimen for a specified period of time, the char length, after-flame and after-glow characteristics are noted.

6.2 Apparatus

6.2.1 A means for providing the atmosphere for conditioning and testing (*see* **6.3.1** and **6.3.2**).

6.2.2 The flammability tester consisting of:

a) *Clip* – A suitable clip for suspending the test specimen above the flame.

b) *Shield* – An incombustible box 305 mm × 305 mm × 760 mm open at the top, and provided with a vertical transparent front. An opening, 25 mm deep and 125 mm long is left at the bottom of the front, to allow manipulation of the gas burner (*see* Fig. 1).

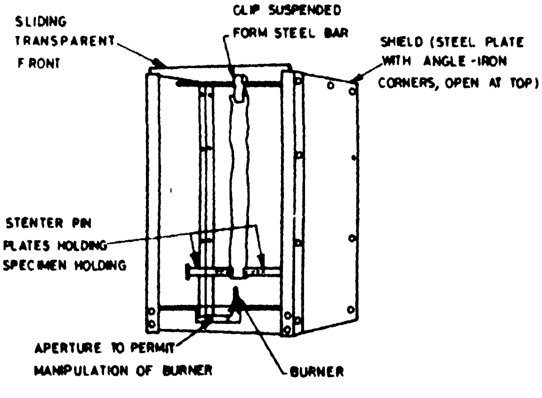

SLIDING TRANSPARENT FRONT
CLIP SUSPENDED FORM STEEL BAR
SHIELD (STEEL PLATE WITH ANGLE-IRON CORNERS, OPEN AT TOP)
STENTER PIN PLATES HOLDING SPECIMEN HOLDING
APERTURE TO PERMIT MANIPULATION OF BURNER
BURNER

FIG. 1 APPARATUS FOR TESTING FLAMEPROOF MATERIALS

c) *Gas burner* – A Bunsen burner about 150 mm high with an internal diameter of 9 mm.

d) *Specimen holder* – Consisting of two U - shaped metal plates between which the fabric specimen can be held in such a way that the fabric specimen is free at the bottom and is held at the top and sides so that the total exposed area is 50 mm × 305 mm. The specimen holder will be positioned in the draught-free box vertically so that the igniting flame strikes the specimen centrally and 19 mm above the bottom edge of the specimen.

e) *Clamps* – These may be plain or serrated spring clips or small clamps. When made of smooth material, it may be necessary to insert emery paper to increase friction.

f) *Weights* – Weights such as are used with laboratory pan balances are satisfactory. A suitable pan may be made from a laboratory balance tray and wire.

g) *Stenter pin plates* – Two stenter pin plates, each consisting of a flat plate carrying pointed pins attached to one side of its broad surface, to prevent movement of the lower end of the test specimen during the application of the test flame. Each plate is secured at one end to the side of the shield in the horizontal position.

6.2.3 *A Stop-watch* – with an accuracy up to 0.1 second.

6.3 Conditioning and Testing Atmospheres

6.3.1 *Conditioning* – Before testing, condition the specimens for 24 h in a standard atmosphere of 65 ± 2 percent relative humidity and 27 ± 2°C temperature (*see* IS 6359:1971 'Method for conditioning of textiles') given in section B-1/1. If the test is not carried out immediately after conditioning, place the specimens in a tightly closed container until the commencement of the test. Each specimen shall be tested within two minutes of removing it from either the conditioning atmosphere or the container.

6.3.2 *Testing Atmosphere* – Carry out the test in a substantially draught-free room or enclosure in an atmosphere of relative humidity between 20 to 80 percent and temperature between 20 to 35°C.

6.4 Test Specimens

6.4.1 The test specimen shall be 315 mm long × 50 mm wide. It shall be prepared in accordance with **6.4.2**.

6.4.2 Six specimens, where appropriate, three in warp direction and three in weft direction shall be cut from the sample (5) so as not to include selvedge (*see* Note). They shall be cut from three widely separated sections of the sample. The specimens shall be conditioned as specified in **6.3.1**.

NOTE — The test specimen should not have loose threads or any form of fringe along its edges, that might affect the ease of ignition, cause initial flaring or flashing and thus prejudice the test.

6.5 Procedure

6.5.1 Keep the apparatus in a substantially draught-free room or enclosure (*see* Note 2) having atmosphere as described in **6.3.2**. Suspend the test specimen from the clip so that it hangs vertically, with its lower end held by the horizontal stenter pin plates in such a way that the bottom 6 mm of the specimen is attached to the horizontal stenter pins thereon. The plates shall be so fixed that not more than 9 mm of the specimen on either side is covered by them.

NOTES

1 In case of fabrics that shrink on burning, specimens may be mounted on suitable specimen holders so that the two long edges are held securely. In this case, the size of each specimen shall be 70 mm × 315 mm so that the total exposed area is 50 mm × 305 mm.

2 Because the test is carried out in a draught-free room, the air in the room is likely to become contaminated with the products of combustion. Where these products include potentially toxic substances, for example, hydrochloric acid, phosphorous compounds, etc, a mask or respirator capable of removing these substances should be worn, or the test may conveniently be carried out in fume hood with the draught shut off. If obnoxious fumes are produced, these may be removed by turning on the draught between the test(s).

6.5.2 Shut off the air supply to the gas burner completely and adjust to give a luminous flame 38 mm in length. Place the gas burner such that the base of the flame is 19 mm below the middle of the lower edge of the specimen. Apply the flame for a period of 12 seconds to the mid-point of the lower edge of the specimen and then withdraw the flame.

6.5.3 Record the duration of flaming, extent of after-glow, the duration of after-glow and occurrence of flashing over the specimen.

6.5.4 When the after-glow has ceased, remove the test specimen from the clip and stenter pin plates and attach two clamps, one on each side of the charred area, 6 mm from lower edge of the test specimen. Attach a weight to one clamp gently so that combined weight is equal to about 10 percent of that required to tear the unburnt material. Measure the length of char or melt to the nearest 5 mm as the difference between the original length of test specimen and the distance of the unexposed edge to the end of the tear made on the test specimen.

NOTES

1 If the material under test is made up of a thermoplastic fibre, it may be necessary to make a small cut vertically (with a pair of scissors or razor blades) through the area of resolidified polymer which extents round the charred areas. The clamps are then attached and the material is tested by the method as described above.

2 In order to determine the weight required to tear the unburnt material, an unburnt specimen is laid on a table and a cut, about 6 mm long, made in the middle of one end. A clamp is attached to the material on each side of the cut, and a weight is attached to the clamp on one side. The material is then gently lifted by the other clamp and the cut is observed. The process is repeated, if necessary, until the minimum weight necessary to tear the material is found. The combined weight of the clamp and attached weights is taken as the weight required to tear the unburnt material.

6.5.4.1 Alternatively, the char length may be measured by the method prescribed in Annex B.

6.6 Report

Report the following separately for each specimen before and after the leaching, washing and/or dry cleaning treatments:

a) Whether or not flashing occurs over the surface of the specimen;
b) Duration of flame (after-flame time) in seconds;
c) Duration of after-glow in seconds;
d) Char length to the nearest 5 mm;
e) Extent of after-glow; and
f) Any abnormal behaviour occurring under the influence of the flame – for example, melting dripping, shrinking from the flame and abnormal charring.

7 METHOD B : THE 45° FLAME TEST

7.1 Principle

Specimens cut from the textile are prepared by brushing if they have a raised fibre surface, by dry cleaning and laundering if they have a flame-retardant finish and by drying. The dried specimen of the fabric is held at an angle of 45° to the horizontal and a standardized flame is applied to the surface near the lower end for 1 s. The time required for flaming to proceed up the fabric a distance of 127 mm is measured. Ignition or fusing of the base of specimens having a raised fibre surface is noted.

7.2 Apparatus

7.2.1 *Flammability Tester*

7.2.1.1 *Draught-proof box*

Consisting of a ventilated draught-proof box (370mm × 220mm × 140mm approx) containing standard ignition mechanism and a specimen rack inclined at 45° and adjustable laterally so that the surface of the tested fabric will be at a standard distance from the micro-burner. For ventilation it shall be provided with 12 holes each 13 mm in diameter equidistantly spaced, near the top of the rear wall and by a slit 300 mm long and 13 mm wide (or any equivalent ventiating strip) below the sliding glazed door. The glazed door slides in grooves at the front of the cabinet. A knob moves the catch mechanism used to hold the sliding door in an open position for insertion of the specimen holders.

7.2.1.2 *Specimen rack*

It provides support for the frames in which the specimens are mounted. The angle of inclination is 45 degrees. Two guide pins projecting downward from the centre of the base of the rack, travel in slots provided in the floor of the chamber so that adjustment can be made for the thickness of the specimen in relation to the flame front. An indicating finger is provided, the forepart of which touches the specimen when the rack is correctly adjusted. Two control knobs hold the rack in test position. The knobs can be reached under the stage of the cabinet and permit forward and backward movements of the rack when loosened.

7.2.1.3 *Specimen holders*

Each specimen holder shall consist of two matched metal U-plates between which the fabric can be held in such a way that the fabric specimen is free at the bottom and is held at the top and sides with 40 mm of width and 150 mm of length exposed. The specimen holder shall be so made that it will drop on the specimen rack into a precisely determined position of 45° inclination and will be positioned in the specimen rack so that the igniting flame strikes the specimen centrally and 6 mm above the bottom edge. Five specimen holders are provided.

7.2.1.4 *Ignition mechanism*

The ignition mechanism shall comprise a micro-burner mounted on a rotatable spindle so that, at the commencement of each test, it moves to a position perpendicular to the surface of the fabric; the respective parts of the apparatus shall be so disposed that the end of the micro-burner is 8 mm above the upper surface of fabric. A flame 16 mm long shall be produced at the micro-burner by butane gas or petroleum gas (*see* Note under **7.3.1**) taken from a small cylinder, a sensitive reducing valve and a manometer device. The ignition mechanism provided shall be such that the flame is maintained in the igniting position for the duration of the test. It shall be provided with means for the timing of the interval (in seconds to the nearest 0.1 second) from the moment of first impingement of the flame on the fabric specimen to the time when the weighed cotton thread is burnt through. The cotton thread is stretched from a guide ring through suitable thread guides provided on the specimen frame and chamber walls, permitting the lacing of the thread in the proper position exactly 127 mm from the point where the centre of the ignition flame impinges on the test specimen. A weight attached by means of a clip to the cotton thread, in dropping, actuates the stop motion.

7.2.1.5 *End point*

The end point of the test is indicated by the burning through of a weighted cotton thread horizontally mounted across the specimen holder 127 mm from the point of ignition and not more than 6 mm above the surface of the specimen.

7.2.2 *Brushing Device*

7.2.2.1 *Movable carriage*

The brushing device consists of a base board over which a small carriage is drawn. This carriage runs on parallel tracks attached to the edges of the upper surface of the base board. A brush is hinged with pin hinges at the rear edge of the base board and rests on the carriage vertically with a pressure of 150 g. The carriage is so constructed as to receive the specimen in its holder and to permit its longitudinal brushing as the carriage is slowly moved beneath weighed brush.

7.2.2.2 *Brush*

40 mm long, comprising two rows of nylon monofil tufts 0.4 mm in diameter and 20 mm in length mounted in a staggered position. There are four tufts per 25 mm and each tuft contains 20 filament ends. The brush is mounted so that it may move freely in a vertical direction and is weighted so that it rests on a horizontal surface with a load of 150 g.

NOTE — For further details, ASTM D 1230-1972 (issued by the American Society for Testing and Materials) may be referred

7.2.3 *Laboratory Drying Oven* -- maintained at 105 ± 3°C.

7.2.4 Desiccator – 250 mm in diameter.

7.2.5 *Mercerized Cotton Sewing Thread*

Corresponding to variety No. 20 of IS 1720 : 1978 'cotton sewing thread'.

7.2.6 *Worsted Test Fabric*

Well scoured, undyed worsted cloth, plain weave, 170 to 180 g/m².

7.3 Reagents

7.3.1 *Butane gas*

NOTE - In place of butane gas, commerically available liquefied petroleum gas (LPG) may also be used

7.3.2 *Calcium Chloride (Anhydrous)*

7.4 Test Specimens

7.4.1 Five test specimens each measuring 150 mm × 50 mm shall be selected as given in **7.4.2** for each test and prepared as described in **7.4.3**.

7.4.2 *Determination of the Type of Specimen*

Before specimens for the standard test are cut, establish by preliminary tests which type of specimen gives the highest observed burning rate. Conduct the preliminary tests as follows:

a) *Unraised fabrics* Test one specimen cut in the warp or length direction of the fabric and one cut in the weft or width direction. If there is a face side to the fabric these specimens shall be tested with the face side uppermost and two additional specimens shall be tested with the face side downwards.

b) *Raised fabrics* - Fabrics raised on one surface only are always tested with the raised surface uppermost. Prepare two specimens cut in the warp direction, and test one with the lie of the nap or pile upwards and one with the lie downwards. Prepare two specimens cut in the weft direction and test these also in both directions with respect to the lie of the nap or pile.

7.4.3 *Preparation of Specimens*

Cut five specimens each of the type shown by preliminary tests (*see* 7.4.2) and of size given in 7.4.1 and mark out on the surface opposite that to be tested, with the long dimensions in the direction in which burning is most rapid as established in the preliminary trials (*see* 7.4.2).

NOTE — The end of each specimen towards which, and on the surface of which, flame spread is most rapid shall be identified by attaching a staple to it. The specimens shall then be cut from the fabric.

7.4.3.1 Each specimen having a raised fibre surface shall be brushed once against the lay of the surface fibres with the brushing device. Other fibres do not require brushing.

7.4.3.2 Condition the specimen in accordance with 7.5.1.

7.5 Conditioning and Testing Atmospheres

7.5.1 *Conditioning*

Dry the specimens for test, already cut and mounted in their holders, for 30 minutes in the ventilated drying oven maintained at 105 ± 3°C. Cool each specimen, still in its specimen holder, in a desiccator or air-tight container over anhydrous calcium chloride for at least 15 minutes. Keep each specimen enclosed until immediately before the test.

7.5.2 *Testing Atmosphere*

Carry out the test in an atmosphere of relative humidity between 20 percent and 80 percent and temperature between 20°C to 35°C.

7.6 PROCEDURE

7.6.1 Set up the flammability tester with its base horizontal. Adjust the specimen rack so that the surface of the fabric to be tested will be 6 mm from the end of the burner in its igniting position. Open the control valve of the fuel supply and allow approximately 5 minutes for the air to be driven from the fuel line. Ignite the gas and adjust the flame so that it burns steadily and has a length of 15 mm measured from the tip of the flame to the nozzle of the burner.

7.6.2 Remove one fabric specimen from the desiccator and place it in position on the specimen rack. The test specimen should be ignited within 45 seconds of the time it was removed from the desiccator. Thread the detecting cotton thread (*see* 7.2.5) through the guides and attach the weight to the cotton thread close to and just below the guide ring. Close the door of the apparatus. Set the stop watch at zero. Conduct the test in a draught-free room with the apparatus under conditions as described in 7.5.2.

7.6.3 Move the ignition flame to the igniting position and immediately start timing mechanism. Apply the flame to the specimen for a period of one second until the cotton thread is severed by the advancing flame. Timing is automatic, starting upon application of the flame and ending when the weight is released by the burning of the detecting cotton thread.

7.6.4 Record the time of flame spread for each specimen and note whether the base of each specimen having raised fibre surface is ignited or fused to a point where the damage is apparent from the bottom of the specimen. Repeat the procedure until all the five specimens have been tested.

NOTE — The time of flame spread is the average time required for flaming to proceed up the fabric specimen to a distance of 127 mm.

7.6.5 Calculate the average of the time of flame spread obtained for the five specimens.

7.6.6 If average time of flame spread (7.6.5) is less than 3½ seconds or if some of the specimens do not burn, test five additional specimens. The time of flame spread of the fabric shall then be the average time for the test specimens, or for the number of specimens that burn.

7.7 Report

The report shall include the folowing:

a) Average time of flame spread for the five or ten specimens or for the number of specimens that burn before and after dry cleaning or washing separately; and
b) The ignition or fusing of the base fabric of textiles having a raised fibre surface when the base fabric of more than one of the five (or two of the ten) specimens tested ignites or fuses, before and after dry cleaning or washing separately.

ANNEX A

(*Clause* 4.1)

LEACHING, WASHING AND DRY CLEANING TREATMENTS OF FABRICS

A-1 LEACHING TREATMENT

A-1.1 General

This treatment is applicable to non-apparel fabrics such as awnings, hatch covers and theatre curtains which would not normally be subjected to water or to dry-cleaning in use but which might be subjected to spot cleaning or casual rinsing, for example, under a tap. It is also used as a preliminary treatment to the drycleaning procedure in order to remove water soluble finishes which, in use, may be affected by wetting. There is no objection to steeping together similar fabrics with the same finish.

A-1.2 Specimens

Use sufficient fabric to permit subsequent preparation of test specimens of the size and number required in Method A or B.

A-1.3 Reagents

A-1.3.1 *Water* – of 160 ± 20 mg/l hardness (expressed as calcium carbonate) from one of the following sources:

a) Supply water of 160 ± 20 mg/l hardness.

b) Supply water of higher than 180 g/l hardness and diluted to 160 ± 20 mg/l hardness with water of lower hardness.

c) Supply water of known initial hardness of '*n*' mg/l where *n* is less than 140 mg/l and artificially hardened to 160 ± 20 mg/l. To 5 litres of the water add 500 ml of the calcium chloride solution (*see* **A-1.3.2**) and follow this with 500 ml of the sodium hydrogen carbonate solution (*see* **A-1.3.3**) and then sufficient of the water to give a total of 10 ± 0.1 litres.

A-1.3.2 *Calcium Chloride Hexahydrate*

43.8 (160 – n) mg/l solution in water of hardness *n* mg/l.

A-1.3.3 *Sodium Hydrogen Carbonate*

33.6 (160 – n) mg/l solution in water of hardness *n* mg/l.

A-1.3.4 *Non-ionic Wetting Agent*

Conforming to IS 9458 : 1994 'Synthetic detergents for washing woollen and silk fabrics'.

NOTE – The exact nature of the wetting agent is not critical.

A-1.4 Apparatus

A-1.4.1 *Flat-Bottomed Dish*

A-1.4.2 *Iron or Press* – to be used at a temperature setting not exceeding 120°C.

A-1.5 Procedure

A-1.5.1 Immerse each specimen in water (*see* **A-1.3.1**) containing 0.5 g/l of non-ionic wetting agent in the flat-bottomed dish at liquor ratio of 1:20 at a temperature of 40 ± 1°C. After 30 minutes, remove the specimen, rinse in the water (*see* **A-1.3.1**) using a liquor ratio of 1:20 for 2 minutes, partially dry the specimens by any method suitable for the fabric type and then iron or press at a temperature setting not exceeding 120°C.

A-2 HARD WATER WASHING TREATMENT USING NEUTRAL SOAP OR SYNTHETIC DETERGENT SOLUTION

A-2.1 General

This treatment is applicable to those fabrics which would normally be subjected to a water wash treatment in use.

A-2.2 Specimens

Use sufficient fabric to permit subsequent preparation of test specimens of the size and number required in Method A or B.

A-2.3 Apparatus

A-2.3.1 A mechanical washing device, for example, wash-wheel sponsored by the Society of Dyers and Colourists or the launderometer sponsored by the American Association of Textile Chemists and Colourists (*see also* IS 1299 : 1984 'Method for determination of dimensional changes on washing of fabrics woven from rayon and synthetic fibres' given in Section C/6) Whichever type of machine is used, the volume of the container should be at least twice that of the washing solution. All the material subjected to washing should be of the type under test; the use of other materials as loading material may give erroneous results.

A-2.4 Reagents

A-2.4.1 *Soap*

Meeting the composition as specified in **7.1** of IS 1299 : 1984 'Method for determination of dimensional changes on washing of fabrics woven from rayon and synthetic fibres' given in Section C/6.

A-2.4.2 *Non-ionic Wetting Agent*

Based on ethylene oxide fatty alcohol condenstate conforming to IS 9458 : 1994. 'Synthetic detergents for washing woollen and other delicate fabrics'.

A-2.4.3 *Sodium Dihydrogen Phosphate* – anhydrous (NaH_2PO_4).

A-2.4.4 *Disodium Hydrogen Phosphate* – anhydrous (Na_2HPO_4).

A-2.4.5 *Hard Water*

With a hardness of 160 ± 20 mg/l (expressed as calcium carbonate) (*see* **A-1.3.1**).

A-2.5 Procedure

A-2.5.1 Treat the specimens in suitable mechanical washing device (*see* **A-2.3.1**) as given in IS 1299 : 1984 'Method for determination of dimensional changes on washing of fabrics woven from rayon and synthetic fibres' given in section C/6 for a period given in **A-2.5.3** with sufficient washing liquor containing 5 g/l soap (*see* **A-2.4.1**) and hard water (*see* **A-2.4.5**) to give a liquor ratio of 1 : 10 (*m/m*).

A-2.5.2 Alternatively, instead of soap, a neutral synthetic detergent solution of following composition may be used: Sodium dihydrogen phosphate, anhydrous (NaH_2PO_4) – 0.1 g/l. Disodium hydrogen phosphate, anhydrous (Na_2HPO_4) – 0.2 g/l. Non-ionic wetting agent of the ethylene oxide fatty alcohol condensate type – 0.05 g/l. Hard Water – to make the required volume.

NOTE — The *p*H of the solution in **A-2.5.2** shall be adjusted to 7.0 ± 0.2.

A-2.5.3 Keep the washing conditions as follows:

Sl No.	*Composition of Fabric*	*Solution Temperature*	*Washing Time, min*
i)	Cotton and linen fibres	80 to 85°C or 60 to 70°C	30
ii)	Polyamide, polyester, regenerated cellulosic fibres	55 to 60°C	30
iii)	Wool, silk and acetate fibres	38 to 40°C	10
iv)	Acrylics, chlorofibres and modacrylic fibres	38 to 40°C	30

A-3 SOFT WATER WASHING TREATMENT

A-3.1 General

This treatment is applicable to those fabrics employed in end uses to which laundering will be applied.

A-3.2 Specimens

Use sufficient fabric to permit subsequent preparation of test specimens of the size and number required in Method A or B.

A-3.3 Apparatus

A-3.3.1 *A Mechanical Washing Device* – (*see* **A-2.3.1**).

A-3.4 Reagents

A-3.4.1 *Water*

With a maximum hardness of 20 mg/l (expressed as calcium carbonate).

A-3.4.2 *Soap*

Meeting the composition specified in **7.1** of IS 1299 : 1984 'Method for determination of dimensional changes on washing of fabrics woven from rayon and synthetic fibres' given in Section C/6 and containing 3 percent sodium carboxymethyl cellulose.

A-3.4.3 *Non-ionic Wetting Agent*

Based on ethylene oxide condensate conforming to IS 9458 : 1994 'Synthetic detergent for washing woollen and silk fabrics'.

A-3.4.4 *Sodium Meta Silicate*

Conforming to IS 9424 : 1979 'Sodium metasilicate'.

A-3.5 Procedure

A-3.5.1 Treat the fabric in a suitable mechanical washing device by the procedure specified in IS 1299 : 1984 'Method for determination of dimensional changes on washing of fabrics woven from rayon and synthetic fibres' given in Section C/6 for a period and at a temperature given in **A-2.5.3** with sufficient washing liquor containing 5 g/l soap, 0.5 g/l non-ionic wetting agent, 3.5 g/l sodium metasilicate and soft water (*see* **A-3.4.1**) to give a liquor ratio of 1 : 10 (*m/m*).

A-4 DRY CLEANING TREATMENT

A-4.1 General

This treatment is applicable to those fabrics which would normally be subjected to a dry cleaning treatment.

A-4.2 Specimens

Use sufficient fabric to permit subsequent preparation of test specimens of the size and number required in Method A or B.

A-4.3 Reagents

A-4.3.1 *Perchloroethylene or Petroleum Ether* - dry cleaning grade.

NOTE — Perchloroethylene should be stored over anhydrous sodium carbonate to neutralize any hydrochloric acid formed

A-4.4 Apparatus

A-4.4.1 Suitable mechanical device consisting of a water bath containing a rotatable shaft which supports, radially, glass or stainless steel containers (75 ± 5 mm diameter × 125 ± 10 mm high) of approximately 550 ± 50 ml capacity, the bottom of the containers being 45 + 10 mm from the centre of the shaft. The shaft/container assembly is rotated at a frequency of 40 ± 2 min^{-1}. The temperature of the water bath is thermostatically controlled to maintain the test solvent at 30 ± 2°C.

NOTE — Other mechanical devices may also be used for the test provided that the results are identical with those obtained by the apparatus described under **A-4.4.1**

A-4.4.2 Glass or stainless steel containers of approximately 550 ml capacity which shall be closed using solvent resistant gaskets.

A-4.4.3 Non-corrodible (stainless) steel discs, 30 ± 2 × 3 ± 0.5 mm, smooth and free from rough edges of mass 20 ± 2 g.

A-4.5 Procedure

A-4.5.1 Prepare a bag with inside dimensions of 10 cm × 10 cm using the undyed cotton twill cloth by sewing together two squares of this cloth around three sides. Place the specimen and 12 steel discs inside the bag. Close the bag by any convenient means.

A-4.5.2 Place the bag containing the specimen and the steel discs in the container and add 200 ml of dry cleaning solvent at 30 ± 2°C. Treat the specimens for 30 minutes at 30 ± 2°C in the specified mechanical device as specified in **A-4.4.1**.

A-4.5.3 Remove the bag from the container, withdraw the specimens, place it between the absorbent paper or cloth and squeeze or centrifuge to remove surplus solvent. Dry the specimen by hanging it in air at a temperature not exceeding 60°C.

ANNEX B

(*Clause* 6.5.4.1)

MEASUREMENT OF CHAR LENGTH

B-1 APPARATUS

B-1.1 A hook and weight assembly. The combined mass of the assembly should be as given in Table 1.

Table 1 Mass to Tear Charred Fabric

Sl No.	Mass of Fabric Being Tested (g/m^2)	Total Mass Used to Tear the Fabric
i)	Less than 200	100
ii)	200 to 600	200
iii)	Greater than 600	400

B-2 PROCEDURE

B-2.1 Inspect the edge of the highest char penetration of the specimen to determine if as a result of thermoplastic behaviour, a thickening of the edge has developed. If this has occurred, make a cut after cooling, only sufficiently deep to cut through the highest portion of this thickened edge of the charred specimen.

B-2.2 Fold the specimen parallel to its length and crease it lightly through the maximum visible portion of the charred length.

B-2.3 Insert the hook with total mass as given in Table 1, in the specimen one side of the charred area, 8 mm in from the adjacent out-side edge of the charred length.

B-2.4 Grasp the specimen with fingers on the opposite side of the charred area and raise gently until it supports the weight. The fabric will tear through the area until fabric strong enough to carry the load is reached.

B-2.5 Measure the distance from the end of the specimen which was exposed to the flame to the end of a tear made lengthwise in the specimen through the centre of the charred area, as the char length.

DETERMINATION OF FLAMMABILITY BY OXYGEN INDEX

(*Source* : IS 13501 : 1992)

Oxygen index results obtained using this method can provide a sensitive measure of the burning characteristics of a textile material intended for clothings under certain controlled laboratory conditions, and hence may be useful for quality control purposes. The results obtained are dependent upon the shape, orientation and isolation of the test specimen and conditions of ignition. For particular materials or applications, it may be necessary or appropriate to specify different test conditions. Results obtained from test specimens of differing thickness or by using different ignition porcedures may not be comparable and no correlation with flammability behaviour under other fire conditions is implied.

Results obtained in accordance with this method must not be used to describe or appraise the fire hazard presented by a particular textile material or shape under actual fire conditions, unless used as one element of a fire risk assessment that takes into account all the factors pertinent to the assessment of the fire hazard of a particular application for the textile material.

1 SCOPE

1.1 It specifies method for determining the minimum concentration of oxygen, in admixture with nitrogen, that will support combustion of small vertical test specimens under specified test conditions. The results are defined as oxygen index values.

1.2 The method provides a sensitive measure of the burning characteristics of textile materials intended for clothings.

2 PRINCIPLE

A small test specimen is supported vertically in a mixture of oxygen and nitrogen flowing upwards through a transparent chimney. The upper end of the specimen is ignited. The minimum concentration of oxygen in a mixture of oxygen and nitrogen flowing upward in a test chimney that will just support combustion is measured under equilibrium conditions of candle like burning. The equilibrium is established by the relation between the heat generated from the combustion of the specimen and the heat lost to the surroundings as measured by one or the other of two arbitrary criteria, namely, the period for which burning continues, or the length of specimen burnt. This point is approached from both sides of the critical oxygen concentration in order to establish the oxygen index.

3 TERMINOLOGY

For the purpose of this standard the definitions given in IS 11871 : 1986 'Methods for determination of flammability and flame resistance of textile fabrics' and the following definition shall apply.

3.1 Oxygen Index

The minimum concentration of oxygen by percentage volume in a mixture of oxygen and nitrogen that will just support combustion of material under specified test conditions.

4 APPARATUS

The following apparatus shall be arranged as indicated in Fig. 1 and 2.

4.1 Test Chimney

A heat resistant glass tube supported vertically on a base through which oxygen-containing gas mixture can be introduced. The preferred dimensions of the chimney are 450 mm minimum height and 75 mm minimum diameter cylindrical bore. The upper outlet shall be restricted as necessary by an overhead cap having an outlet small enough to produce an exhaust velocity of at least 90 mm/s from a flow rate within the chimney of 30 mm/s (*see* Note). Chimneys of other dimensions, with or without restricted outlets, may be used, if shown to give equivalent results. The bottom of the chimney, or the base upon which the chimney is supported, shall incorporate a means for distributing evenly the gas mixture entering the chimney. The preferred means comprises solid glass beads of between 3 and 5 mm diameter, in a layer between 80 and 100 mm deep. Other means, such as radial manifolds, may be used, if shown to give equivalent results. A porous screen may be mounted below the level of the specimen holder, to prevent falling combustion debris from fouling the gas entry and distribution paths. The chimney support may incorporate a leveling device and indicator, to facilitate vertical alignment of the chimney and a test specimen supported therein. A dark background may be provided to facilitate observation of flames within the chimney.

NOTE — For tubes of 75 to 100 mm diameter, a cap converging to an outlet of 40 mm diameter at a level at least 10 mm above the top of the cylindrical chimney has been found satisfactory.

4.2 Test Specimen Holder

Suitable for supporting a specimen vertically in the centre of the chimney. The specimen shall be supported by both vertical edges in a frame equivalent to that illustrated in Fig. 2, with reference marks at 20 mm and 100 mm below the top of the frame. The profile of the holder and its support should be smooth to minimize induction of turbulence in the rising flow of gas.

4.3 Gas Supply

Comprising commercial grade oxygen and nitrogen. If an air supply is used with oxygen or nitrogen, it shall be clean and dry. The gas supply system shall incorporate a drying device. The constituent gas supply lines shall be linked in a manner which thoroughly mixes the gases, before they enter the gas distribution device at the base of the chimney, so that the variation in oxygen concentration in the gas mixture rising in the chimney, below the level of the test specimen, is less than 0.2 percent (*v*/*v*).

4.4 Gas Measurement and Control Devices

Suitable for establishing the concentration of oxygen and nitrogen in the gas mixture entering the chimney with an accuracy of ± 1.0 percent (*v*/*v*).

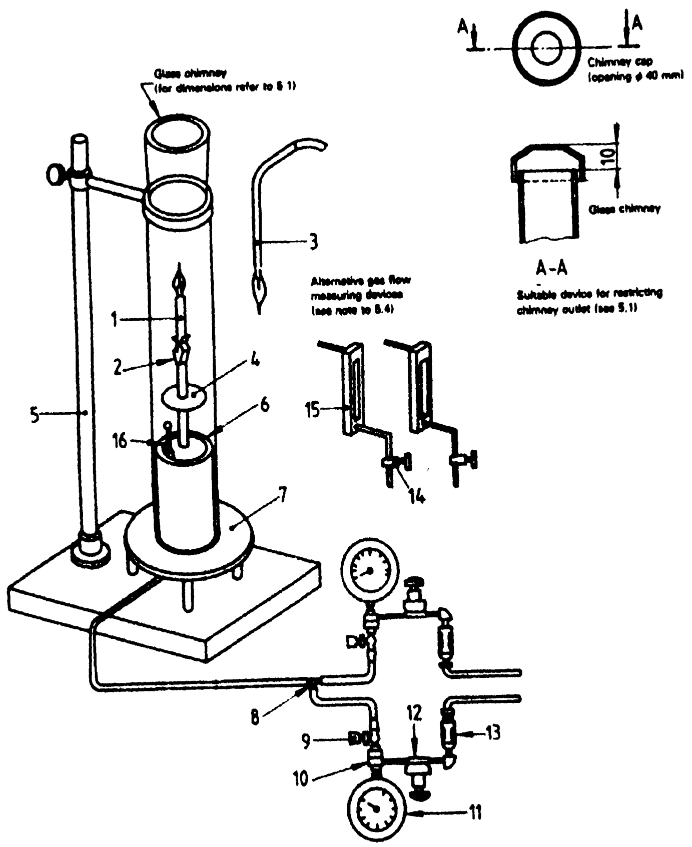
NOTE — System of measurement and control that have proved satisfactory include the following:

a) Needle valves on individual and mixed gas supply lines, a paramagnetic oxygen analyzer that continuously samples the mixed gas, and a flowmeter to indicate when the gas flow through the chimney is within required limits;

b) Calibrated orifices, gas pressure regulators and pressure gauges on the individual gas supply lines; or

c) Needle valves and calibrated flowmeters on the individual gas supply lines.

Systems (b) and (c) may require calibration after assembly to ensure that the compounded errors of the component parts do not exceed the requirements of 4.4.


Glass chimney
(for dimensions refer to 5.1)
Chimney cap
(opening ϕ 40 mm)
A
A
10
Glass chimney
A-A
Suitable device for restricting chimney outlet (see 5.1)
Alternative gas flow measuring devices (see note to 5.4)
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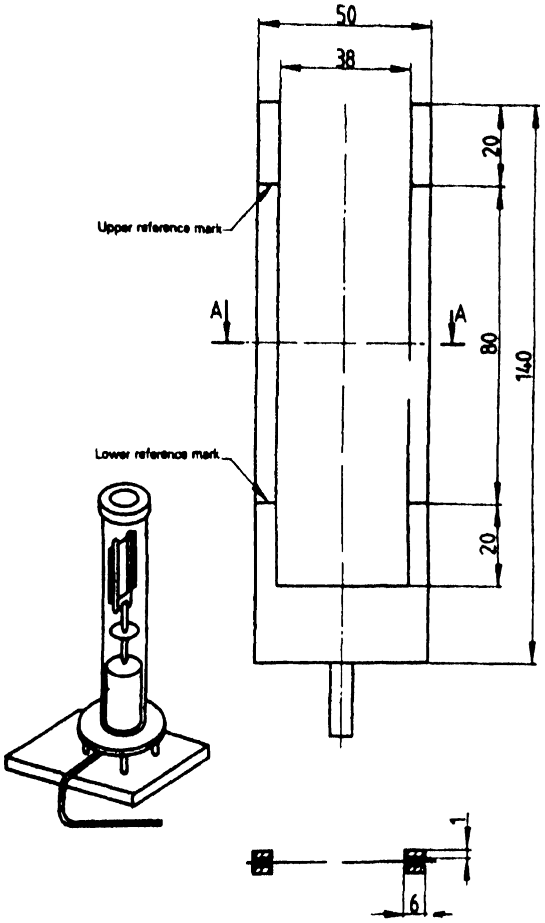
1. Burning test specimen
2. Specimen holder
3. Igniter
4. Debris screen of wire mesh
5. Chimney support
6. Bead bed
7. Base plate
8. Gas premixing point
9. Cut-off valve
10. Orifice in holder
11. Pressure gauge
12. Precision pressure regulator
13. Filter
14. Needle valve
15. Gas flow meter
16. Temperature sensor

FIG. 1 DIAGRAM OF TYPICAL APPARATUS FOR DETERMINATION OF OXYGEN INDEX



All dimensions in millimetres with tolerances ± 0.25 mm

FIG. 2 FRAME DESIGN FOR SUPPORTING NON-SELF-SUPPORTING TEST SPECIMENS

4.5 Flame Igniter

Comprising a tube that can be inserted into the chimney to apply to the test specimen a flame issuing from an outlet of 2 ± 1 mm diameter at the end of the tube. The flame fuel shall be commercially available liquefied petroleum gas (LPG). The fuel supply shall be adjusted so that the flame will project 6 to 25 mm vertically downwards from the outlet when the tube is vertical within the chimney and the flame is burning within the chimney atmosphere.

4.6 Timing Device

Capable of measuring periods up to 10 min with an accuracy of 5 seconds.

4.7 Soot, Fumes Heat-Extraction System

Providing sufficient ventilation or exhaust to remove fumes or soot expelled from the chimney without disrupting the gas-flow rate or temperatures in chimney.

NOTES

1 If soot-generating materials are being tested, the glass chimney may require cleaning to maintain good visibility, and the gas inlets, or inlet screen, and temperature sensor (if fitted) may also require cleaning to function properly. Suitable precautions should be taken to protect personnel from noxious materials or burns during testing or cleaning operations.

2 Any other suitable oxygen analyzer equipment based on the principle specified in this method and capable of giving reliable and reproducible results directly, may also be used.

5 CALIBRATION OF EQUIPMENT

5.1 For compliance with this method, calibrate the equipment periodically in accordance with the instructions given in Annex A so that the maximum interval between recalibration and use complies with the periods stated in Table 1.

Table 1 Equipment Calibration Frequencies
(*Clause* 5.1)

Item	Maximum Period
Gas-flow rate controls	6 months
Oxygen concentration controls	6 months
Gas system joints (as required by A-2 in Annex A):	
a) for joints disturbed use or cleaning of the apparatus	24 hours
b) for undistrubed joints	6 months

6 PREPARATION OF TEST SPECIMENS

6.1 Sampling

Obtain a sample sufficient for preparation of 5 to 10 test specimens. The sample shall be taken, if relevant, in accordance with the materials specification or otherwise specified.

NOTE — For a material for which the oxygen index is known to within ± 2, 5 test specimens may be sufficient. For materials of unknown oxygen index, or which exhibit erratic burning characteristics, between 8 and 10 test specimens may be required.

6.2 Test Specimen Dimensions and Their Preparation

Cut test specimens of size 140 ± 5 mm × 52 ± 0.5 mm. Ensure that the surfaces of the specimens are clean and free from flaws that could affect burning behaviour. The edges of the specimens shall be relatively smooth and free from furr or burrs of material left from machining.

6.3 Marking of Test Specimens

For monitoring the distance over which a specimen burns, it may be marked with transverse lines at one or more levels which are dependent upon the specimen form and the ignition procedure to be used. If wet inks are used, the marks shall be dry before the specimen is ignited.

6.3.1 The reference marks for testing specimens are carried by the supporting frame (*see* Fig. 2).

6.4 Conditioning and Testing Atmospheres

6.4.1 *Conditioning*

Before testing, condition the specimens for 24 hours in a standard atmosphere of 65 ± 2 percent relative humidity and 27 ± 2°C temperature (*see* IS 6359 : 1971 'Method of conditioning of textiles' given in Section B-1/1). If the test is not carried out immediately after conditioning, place the specimens in a tightly closed container until the commencement of the test. Each specimen shall be tested within two minutes of removing it from either the conditioning atmosphere or the container.

6.4.2 *Testing Atmosphere*

Carry out the test in a substantially draught free room or enclosure in an atmosphere of relative humidity between 20 to 80 percent and temperature between 20 to 35°C.

7 PROCEDURE

7.1 Setting up the Apparatus and Test Specimen

7.1.1 Recalibrate equipment components, if necessary (*see* **5.1** Annex A).

7.1.2 The test shall be conducted in the testing atmosphere specified in **6.4.2**.

7.1.3 Select an initial concentration of oxygen to be used. When possible, this may be based on experience of results for similar materials. Alternatively, try to ignite a test specimen in air, and note the burning behaviour. If the specimen burns rapidly, select an initial concentration of about 18 percent (*v/v*) of oxygen; if the test specimen burns gently or unsteadily select an initial oxygen concentration of about 21 percent (*v/v*); if the specimen does not continue to burn in air, select an initial concentration of at least 25 percent (*v/v*), depending upon the difficulty of ignition or the period of burning before extinguishment in air.

7.1.4 Ensure that the test chimney is vertical (*see* Fig. 1). Mount a specimen vertically in the centre of the chimney so that the top of the specimen is at least 100 mm below the open top of the chimney and the lowest exposed part of the specimen is at least 100 mm above the top of the gas distribution device at the base of the chimney (*see* Fig. 1 or Fig. 2 as appropriate).

7.1.5 Set the gas mixing and flow controls so that an oxygen/nitrogen mixture containing the desired concentration of oxygen is flowing through the chimney at a rate of 40 ± 10 mm/s. Allow the gas to flow for at least 30 seconds to purge the system prior to ignition of each specimen, and maintain the flow without change during ignition and combustion of each specimen. Ignite the test specimen as described in **7.2**.

7.1.6 Record the oxygen concentration used as the volume percent calculated according to the equations given in Annex B.

7.2 Igniting the Test Specimen

7.2.1 Apply the lowest visible part of the flame to the top of the specimen using a sweeping motion, if necessary, to cover the whole surface, but taking care not to maintain the flame against the vertical faces or edges of the specimen. Apply the flame for up to 30 seconds, removing it every 5 seconds for just sufficient time to observe whether or not the entire top surface of the specimen is burning.

7.2.2 Consider the specimen to be ignited, and commence measurement of the period and distance of burning, as soon as removal of the igniter, after a contact period increment of 5 seconds, reveals, burning supported by the whole of the top end surface of the specimen.

7.3 Assessing Burning Behaviour

For the purposes of 7.3.2 to 7.3.4 inclusive, observe and terminate the burning of individual test specimens as follows.

7.3.1 Commence measurement of the period of burning as soon as the specimen has been ignited in accordance with 7.2, as applicable, and observe its burning behaviour. If burning ceases but spontaneous re-ignition occurs in less than 1 second, continue the observation and measurements.

7.3.2 The concentration of oxygen is too high and must be reduced if the specimen burns and either the period or the extent of burning exceeds the relevant limits specified in Table 2. The concentration oxygen must be raised if the flaming of the specimen extinguishes before meeting the criteria specified in Table 2. Do not adjust the oxygen concentration after igniting the specimen.

Table 2 Criteria for Oxygen Index Measurements
(*Clauses* 7.3.2 *and* 7.3.4)

Period of Burning After Ignition (Seconds)	Extent of Burning
180	580 mm below the top of the specimens

NOTE — These criteria do not necessarily produce equivalent oxygen index results for specimens of differing shape or tested using different conditions or procedures.

7.3.3 Adjust the oxygen concentration, insert a new specimen, or if the previous specimen is long enough, turn it end for end or cut off the burnt end, then purge and re-ignite.

7.3.4 Continue repeating 7.1.5 to 7.3.3 until the critical concentration of oxygen is determined. This is the lowest oxygen concentration that will meet the criteria specified in Table 2. At the next lower concentration that will give a difference in oxygen index of 0.2 percent or less, the specimen should not meet the criteria specified in Table 2.

NOTES

1 The critical oxygen concentration has been found to be dependent on the temperature of the specimen at ignition and the temperature of the gas mixture.

2 For a material having consistent burning characteristics, the difference in oxygen concentration between and extinguishing as specified in 7.3.2 will be reproducible within 0.1 percent to 0.3 percent depending on the sensitivity of the flow measuring equipment and upon the particular oxygen concentration involved. Some materials, however, exhibit erratic burning characteristics because of inhomogeneity, char formation, dripping, bending, etc, which cause less reproducible results. In such cases, the critical concentration may be determined by a statistical testing method as given in American Statistical Association Journal, pp-967-970 (1965).

7.3.5 Perform the test at least three times by starting at a slightly different flow rate still within 30 to 50 mm/second limits and again performing the procedure from 7.1.5 to 7.3.4.

8 CALCULATIONS

8.1 Calculate the oxygen index, *n*, of the material for each replicate in 7.3.5 by the formula:

$$n = \frac{100\ O_2}{O_2 + N_2}$$

where

O_2 = the volumetric flow of oxygen in cm^3/s, at the concentration determined in 7.3.4; and

N_2 = the corresponding volumetric flow rate of nitrogen in cm^3/s.

NOTE — If an oxygen analyzer is used, the oxygen index should be determined using the readout from the particular instrument used.

8.1.1 If air is used and either oxygen or nitrogen is added as required, calculate *n* assuming that air contains 20.9 percent oxygen as follows:

$$n = \frac{(100 \times O_2) + (20.9 \times A)}{(O_2 + N_2 + A)}$$

where

A = the volumetric flow rate of air in cm^3/s.

9 TEST REPORT

The test report shall include the following:

a) Identification of the material tested, including, where relevant, the type of material, density, previous history, and the specimen orientation with respect to any anisotropy in the material or sample;

b) The test specimen dimensions;

c) The igniter used;

d) The individual oxygen index values found for each of the tests, and average index value;

e) A description of any relevant ancillary characteristics or behaviour, such as charring, dripping, severe shrinkage, erratic burning after-glow;

f) Any variations from the requirements of this standard; and

g) Any other information required by the law in force.

ANNEX A

(*Clauses* 5.1 *and* 7.1.1 and *Table* 1)

CALIBRATION OF EQUIPMENT

A-1 CALIBRATION OF GAS FLOW RATE CONTROLS

A-1.1 Check the system for indicating the gas-flow rate through the chimney using a water-sealed rotating drum meter (wet test meter), or an equivalent device, with an accuracy equivalent to ± 2 mm/s flow rate through the chimney.

A-1.2 Estimate the flow rate by dividing the total gas-flow rate through the chimney by the cross-sectional area of the bore of the chimney, for example by using the equation.

$$F = 1.27 \times 10^6 \frac{q_v}{D^2}$$

where

F = the flow rate through the chimney, in mm per second;

q_v = the total gas-flow through the chimney, in litres per second;

D = the diameter of the bore of the chimney, in millimeters.

A-2 CALIBRATION OF OXYGEN CONCENTRATION CONTROLS

A-2.1 Check the concentration of oxygen in the mixture of gases flowing into the chimney to an accuracy of 0.1 percent (*v/v*) of mixture, either by sampling the chimney atmosphere for analysis or by using an independently calibrated oxygen analyzer *in-situ*, integral oxygen analyzers may be calibrated using standard oxygen/nitrogen mixtures. The checks should be carried out for at least three different nominal concentrations, representating respectively maximum, minimum and intermediate levels for the oxygen concentration range for which the equipment is to be used.

A-2.2 Carry out leak-tests on all joints where leaks could change the oxygen concentration levels in the chimney from the concentration levels set or indicated.

A-3 CALIBRATION OF COMPLETE EQUIPMENT

A-3.1 Check the performance of the equipment for a specific test procedure, by testing a calibrated material and comparing the measured results with the expected result for the calibrated material. For information on the availability and use of calibrated materials, *see* Annex B.

ANNEX B

(*Clauses* 7.1.6 *and* A-3.1)

CALCULATION OF OXYGEN CONCENTRATION

B-1 Calculate the oxygen concentrations according to the following equation:

$$C_0 = \frac{100V_0}{V_0 + V_N}$$

where

C_0 = oxygen concentration, in percent by volume;
V_0 = volume of oxygen per volume of mixture; and
V_N = volume of nitrogen per volume of mixture.

NOTES

1 If an oxygen analyzer is used, the oxygen concentration should be determined using the readout from the particular instrument used.

2 If the result is calculated from flow or pressure date for individual gas streams contributing to the mixture, it is necessary to allow for the proportion of oxygen present in streams other than a pure oxygen supply. For example, for mixtures made using air mixed with oxygen of 98.5 percent (*v/v*) purity or with nitrogen containing 0.5 percent (*v/v*) of oxygen, the oxygen concentration, in percent by volume, should be calculated using the relationship:

$$C_0 = \frac{98.5V_0' + 20.9V_A' + 0.5V_N'}{V_0' + V_A' + V_N'}$$

where

V_0' = the volume of oxygen stream used, per volume of mixture;
V_A' = the volume of air stream used, per volume of mixture; and
V_N' = the volume of nitrogen stream used, per volume of mixture.

Assuming that the streams are at the same pressure and temperature.

For mixture based on two gas streams, V_0', V_A' and V_N' becomes zero, as appropriate.

DETERMINATION OF THE IGNITABILITY OF UPHOLSTERED COMPOSITES FOR SEATING FOR FURNITURE BY SMOKERS' MATERIALS

(*Source* : IS 12467 : 1988)

The ignitability of upholstered composites for seating for furniture depends to a large extent on the design and materials employed in a piece of furniture. The tests carried out on these component materials in isolation may not give true indication of their behaviour when combined with other component materials in a piece of furniture. Therefore, to evaluate the ignitability of an item of seating, it is necessary to test the complete finished item of furniture. However, in view of very wide range of designs and materials employed, the method prescribed in this standard has been chosen to test upholstery materials combined together to give information regarding the ignitability properties of assemblies that might be used in number of different circumstances.

The position at which accidentally dropped cigarettes are most likely to cause ignition is the angle between vertical and horizontal surfaces. In this test, for evaluating assemblies of materials, this point has been taken care of, even though in practice an assembly might only be used on a single surface. The results, therefore, provide a measure of the ignitability of a combination of cover and filling which is equally valid for the different designs of furniture or the different applications in that furniture in which the combination might be used.

It prescribes a method for examining the ignitability properties of upholstery assemblies when subjected to smouldering cigarette. Modifications that may be made to examine more specific furniture design features are described in Annex A.

The results of this method relate to the behaviour of test specimens as supplied under particular conditions of test and do not take into consideration the effects of ageing, washing, soiling, etc, that may be encountered during the life of the product. It may be recognized that this method cannot give a full assessment of fibre properties in all situations. Measures taken to reduce the ignitability of an assembly may adversely affect other fire properties such as smoke and toxic gas evolution, and this aspect requires separate consideration.

1 SCOPE

It prescribes a method for assessing the ignitability of material combinations, for example, covers and filling used in upholstered seating when subjected to a smouldering cigarette as might be applied accidentally in the use of upholstered seats. It does not cover ignition caused by deliberate acts of vandalism.

2 DEFINITION

For the purpose of this standard, the following definition shall apply :

2.1 Progressive Smouldering

An exothermic oxidation not accompanied by flaming which is self-propagating, that is, independent of the ignition source. It may or may not be accompanied by incandescence.

NOTE — In practice, it has been found that there is usually a clear distinction between materials which may char under the influence of the ignition source but which do not propagate further (non-progressive) and those where smouldering develops in extent and spreads (Progressive).

3 PRINCIPLE

An assembly of upholstery material is arranged in stylized form as a joint between the seat and back (or seat and arm) surfaces of a chair and exposed to an ignition source of a smouldering cigarette. The progressive smouldering and flaming of the interior and the cover of the material is observed and recorded as a pass or fail result.

4 HEALTH AND SAFETY OF OPERATORS

4.1 General

There is a considerable risk with this test and precautions have to be taken.

4.2 Enclosure

For safety, the test should be conducted in a suitable fume cupboard. If such a cupboard is not available, an enclosure should be constructed so that the tester is not exposed to the fumes (*see* **8.1**).

4.3 Extinguishers

Accessible means of extinguishing the samples should be provided, for example, a bucket of water, a fire blanket or fire extinguisher.

5 APPARATUS

5.1 Test Rig

A suitable test rig is illustrated in Fig. 1 and 2. It shall consist of two rectangular frames hinged together and capable of being locked at right angles to each other.

5.1.1 The frames shall be made from nominal 25 mm × 3 mm steel flat bar and shall securely hold expanded steel platforms set 6 ± 1 mm below the top edge of the frames.

NOTE — The size of the mesh of the expanded steel is not critical but a mesh size across the diagonals of approximately 28 mm × 6 mm has been found suitable.

5.1.2 The internal width and height of the back frame shall be 450 ± 2 mm × 300 ± 2 mm, and the width and depth of the base frame shall be 450 ± 2 mm × 150 ± 2 mm. A standard edging section may be used around the expanded steel to give protection and greater rigidity.

5.1.3 The sides of the frames shall extend beyond the back of each frame to provide for the hinge holes and to form the back legs. The hinge rod shall be of nominal 10 mm diameter steel, continuous across the back of the rig and its axis 225 ± 0.5 mm beyond the back member of each frame.

5.1.4 The frames shall be lockable at right angles by a bolt or pin through each of the pairs of members forming the back legs. The front legs may be welded across the front corners of the base frame. The height of the legs shall be such as to leave a gap not less than 50 mm high between the base frame and the supporting surface.

5.1.5 For the test, rig shall be sited with the enclosure (*see* **4.2**) and the testing shall be performed in a substantially draught-free environment permitting an adequate supply of air.

5.2 Smouldering Cigarettes Source – An untipped cigarette complying with the following requirements is needed:

Length	:	68 mm approximately
Diameter	:	8 mm approximately
Mass	:	1 g nominal
Smouldering rate	:	12.0 ± 3.0 min/50 mm

5.2.1 The smouldering rate shall be verified as follows on one sample from each batch of 10 cigarettes used : Mark the cigarette, conditioned as described in **6.1** at 5 mm and 55 mm from the end to be lit. Light it as described in **8.3.1** and impale it horizontally in draught-free air on a horizontal wire spike inserted not more than 13 mm into the unlit end. Record the time taken to smoulder from the 5 to 55 mm marks.

6 ATMOSPHERE FOR CONDITIONING AND TESTING

6.1 Conditioning

Before testing, condition the specimen of material to be tested and the cigarette for 24 h in a standard atmosphere of 65 ± 2 percent relative humidity and 27 ± 2°C temperature (*see* IS 6359 : 1971 'Method for conditioning of textiles' given in Section B-1/1). If the test is not carried out immediately after conditioning, place the specimen and the cigarette in a tightly closed container until the commencement of the test. Each specimen shall be tested within 2 minutes of removing it from either the conditioning atmosphere or the container.

6.2 Testing

Carry out the test in a substantially draught-free room or enclosure in an atmosphere or relative humidity between 20 and 80 percent, and temperature between 20 and 35°C.

7 TEST SPECIMENS

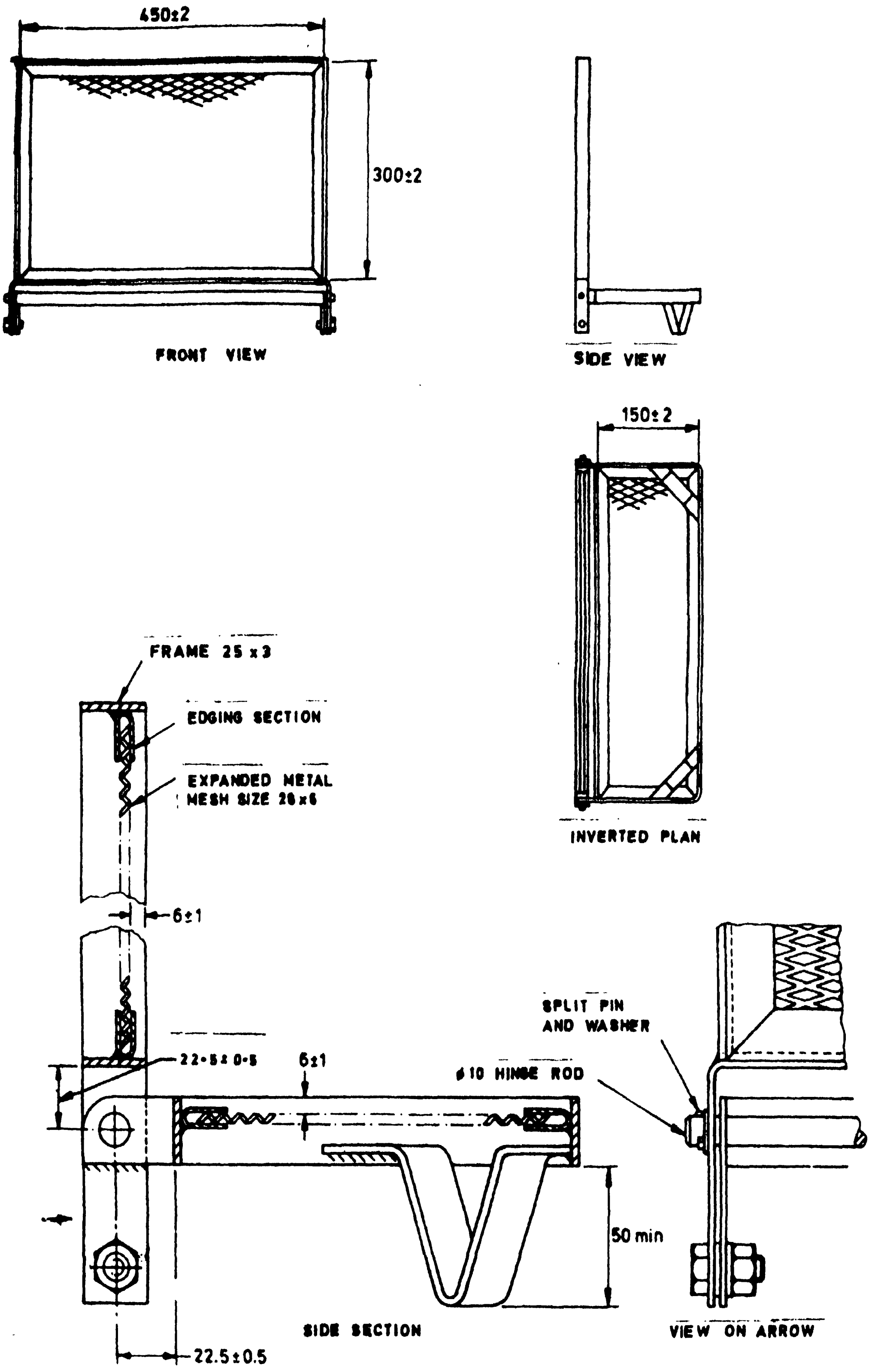
7.1 General

The test piece materials shall be representative of the cover, filling and any other components to be used in the final assembly.

7.2 Cover Material and Fabric Interliner

7.2.1 The cover size needed for each test shall be 800 ± 10 mm × 650 ± 10 mm. The long dimension shall be cut parallel to the selvedges. The cover may be constructed from smaller pieces of material provided that the location of the resulting seams does not occur within 100 mm of the area likely to be affected by the test.

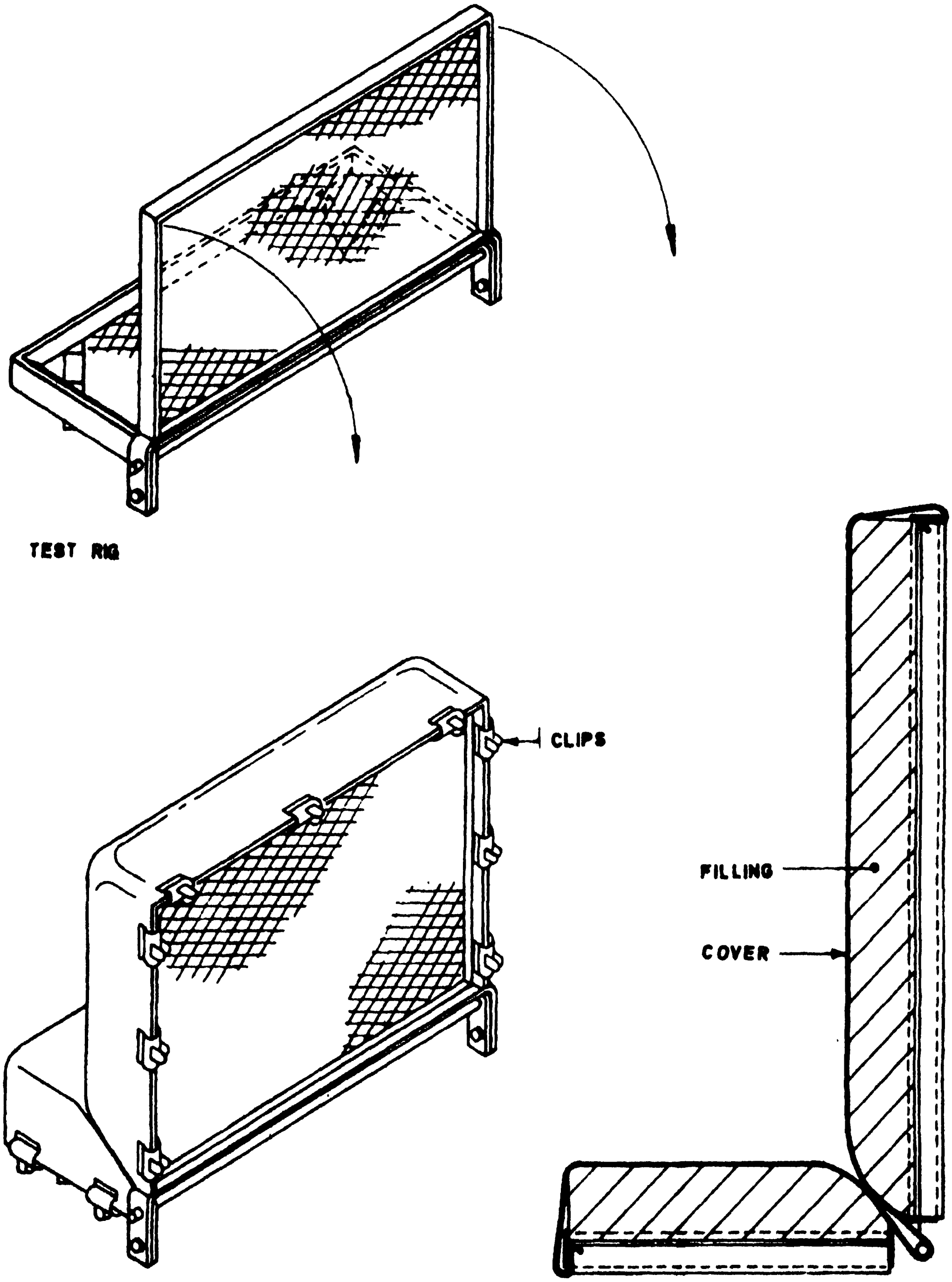
7.2.2 The cover shall have triangular cut-outs 325 mm from one end of both sides. The cut outs shall be positioned such that when assembled on the test rig



All dimensions in millimetres.

ALL PARTS ARE OF STEEL

FIG. 1 TEST RIG DETAIL



TEST RIG

TEST RIG WITH COVER AND FILLINGS

VERTICAL SECTION

FIG. 2 TEST RIG ASSEMBLY

the lie of any pile is down the back assembly and from the hinge to the front of the base frame. The size of these cut-outs shall be approximately 50 mm base and 110 mm high. Where a fabric interliner is used, it shall be cut to the same dimensions and in the same orientation as the cover for fitting to the test rig under the cover.

7.3 Upholstery Filling

Two pieces, one 450 ± 5 mm × 300 ± 5 mm × 75 ± 2 mm thick, and the other 450 ± 5 mm × 150 ± 5 mm × 75 ± 2 mm thick shall be used for each test.

7.3.1 Some cushioning assemblies may consist of several layers that may be typically felt, wadding or different foams. In these cases, the test pieces shall reproduce the upper 75 mm of the cushioning assembly.

7.3.2 Where the filling is less than 75 mm thick, the test piece shall be built up to the required thickness by adding to the underside a further layer of the bottom material.

8 TEST PROCEDURE

8.1 Warning

For safety, all tests should be carried out in a suitably constructed fume enclosure (*see* **4.2**).

8.2 Preparation

8.2.1 Ensure that the means of extinguishing are close to hand (*see* **4.3**).

8.2.2 Open out the test rig and thread the covering fabric and, if any, the fabric interliner behind the hinge bar.

8.2.3 Place the filling pieces under the covering fabric and, if any, the fabric interliner locating the filling pieces in the frame recesses, and allowing approximately 20 mm of fabric to wrap round the inside of the frames.

8.2.4 Lock the frames at right angles by the bolts or pins ensuring that the filling components are not displaced.

8.2.5 Fasten the fabric over the top, bottom and sides of the frame using clips and ensure that the fabric(s) is secured and under even tension.

8.3 Procedure

8.3.1 Light a cigarette (*see* **5.2**) and draw air through it until the tip glows brightly. Not more than 8 mm of the cigarette shall be consumed in this operation.

8.3.2 Place the smouldering cigarette in position along the junction between the vertical and horizontal test pieces, allowing at least 50 mm from the nearest side edge, or from any marks left by previous test, to the cigarette and simultaneously start the clock.

8.3.3 Observe the progress of combustion and record any evidence of progressive smouldering (*see* **2.1**) or flaming in the interior and/or cover.

NOTE — The detection of smouldering may be difficult and is eased by watching for smoke emerging at points at a distance from the cigarette. Smoke is most easily viewed by looking down a rising column by means of a mirror.

8.3.4 If progressive smouldering or if flaming of the upholstery components is observed at any time within a period of one hour of the placement of the cigarette, extinguish the test piece and record a failed result for the smouldering cigarette test.

8.3.5 If progressive smouldering or if flaming is not observed within the one hour period or if the cigarette fails to smoulder its complete length, repeat the test with a new cigarette placed in a fresh position not less than 50 mm from any previous test damage. If progressive smouldering or if flaming is not observed in this retest or if the cigarette fails to smoulder its complete length, record a pass result for the smouldering cigarette test, unless the test piece fails the final examination specified in **8.4**. Otherwise extinguish the test piece and record a failed result.

NOTE — The repeat test may be run concurrently with the last test (*see* **8.4**).

8.4 Final Examination

Immediately after completion of the test programme on the assembly dismantle and examine it internally for progressive smouldering. If this is present, extinguish the test piece and record a failed result for the relevant test source. For safety reasons, ensure that all smouldering has ceased before the rig is left unattended.

9 REPORT

9.1 The report shall include the following:

a) The following test result relate only to the ignitability of the combination of materials under the particular conditions of test; they are not intended as a means of assessing the full potential fire hazard of the material in use:

b) The identification and construction of the test samples;
c) The test result, pass or fail; and
d) The name, initials or tade-mark of the manufacturer.

9.2 The report shall contain details of any features of the test pieces or procedures that may have affected the results. Such features are:

a) Conditioning of the test sample;
b) Special features of burning, for example, melting, drippings, charring and development of flames from smouldering; and
c) Times of major events, for example, ignition of test pieces, cover splitting and extinction.

ANNEX A

GUIDELINES FOR DESIGNERS AND SPECIFIERS

A-1 This test method prescribes method for examining the ignitability, in defined circumstances, of an assembly of upholstery materials. These materials are combined together in a way intended to be generally representative of their end use in upholstered seating, and the ignition source is a smouldering cigarette. Thus the potential ignitability of using a particular cover, filling and interliner in combination can be assessed and this will allow the development of specifications concerned with ignition by smokers' materials. However, there are two important limitations, as follows:

a) The test is concerned only with ignitability, and any controls of fire hazard have to consider, in addition, other aspects of fire performance such as rate of fire development heat output, rate and quantity of smoke production, and toxic gas evolution. Ideally, any attempts to reduce ignitability ought not to affect these other properties adversely.

b) The tests only measure the ignitability of a combination of materials used in upholstered seating and not of a particular finished item of furniture incorporating these materials. They give an indication of, but can not guarantee, the ignition behaviour of the finished item of furniture. This limitation occurs because design features of the furniture can greatly affect its fire properties; any ignitability tests of a piece of furniture would therefore need to be carried out on the actual item and not on component materials or mock-ups. However, limited information on ignitability more specifically related to an intended design may be obtained as indicated in **A-2** and **A-3**.

A-2 This test method prescribes laboratory test of an assembly of materials which will give general guidance on the ignitability of finished furniture, but where more specific information is required, or in critical areas of end use, the principles may be applied to complete items or components of furniture or to suitable modified test assemblies, some examples of which are given below. In such cases the source described in **5.2** may be applied at positions which, as a general rule, correspond to those where the hazard of ignition occurs in use:

Example 1 – If a chair were to have a gap between the seat and back cushions, the placement of ignition source in the angle of the tests apparatus would be inappropriate. Instead, face ignition, where the sources are placed at the centre of the horizontal and vertical surfaces, would be more meaningful.

Example 2 – The test apparatus may be used to model the junction of any vertical and horizontal surfaces so that both arm and back constructions if different, may be tested separately in conjunction with the seat.

Example 3 – The use of diferent materials in a back and seat of chair may be reproduced in the test, two different cover fabrics being joined by sewing or staples behind the hinge bar.

Example 4 - If in the final design a loose cushion is to be placed on an upholstered seat platform, additional cigarette traps are produced between the loose cushion and the surrounding upholstery. This may be examined by using the larger test rig and test pieces by constructing a loose cushion of the appropriate materials measuring 500 ± 5 mm × 750 ± 2 mm to be placed on top of the horizontal surface of the normally assembled test arangement.

A-3 Another way in which this principle might be used is to give information about individual materials to be used in a combination. For example, the ability of a cover material to provide protection against ignition can be indicated by testing it in combination with a substrate of known flammability; standard non-flame retardant flexible polyether foam with a density of about 22 kg/m^3 has been found to be suitable. Such information about the individual materials does not eliminate the need to test the actual combination, but it can help in the short listing of material combinations and so reduce the over all amount of testing required.

EVALUATING THE RELATIVE EFFICIENCY OF WETTING AGENTS FOR MERCERIZATION

(*Source* : IS 5151 : 1969)

To facilitate uniform, thorough and speedy impregnation of textile materials which is much desired in mercerizing, wetting agents are extensively used. From among the varieties of commercial wetting agents, the textile processor has to choose the one suitable for his requirements. This test method is used to assess the relative efficiency of wetting agents.

1 SCOPE

This standard prescribes two methods for evaluating the relative efficiency of wetting agents used in the mercerization of cotton textiles.

2 PRINCIPLE

In the first method the time required for complete wetting of a bundle of yarn of canvas disc in caustic soda solution containing the wetting agent is determined. For the same concentration of different wetting agents, lesser the wetting time, higher is the efficiency of wetting agent. In the second method, a single cotton thread is allowed to contract in caustic soda solution containing the wetting agent for definite time and the contraction is determined. Higher the contraction, more efficient is the corresponding wetting agent.

3 REAGENTS

3.1 Quality of Reagents

Unless specified otherwise pure chemicals shall be employed in tests and distilled water shall be used where the use of water as reagent is intended.

NOTE — 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the test results.

3.2 Caustic Soda Solution – 300 g/l.

NOTE — The solution should be allowed to stand and supernatant clear solution be used.

4 FIRST METHOD

4.1 Apparatus and Materials

4.1.1 *Beakers or Glass Jars* – of 600 ml capacity.

4.1.2 *Measuring Pipettes* – graduated in 0.05 ml.

4.1.3 *Measuring Flask* – of 500 ml capacity.

4.1.4 *Stop-watch* – to read correct to one-tenth of a second.

4.1.5 *A Special Holding Device* – made of stiff stainless steel wire with a coil about 50 mm in diameter at one end and a hook in the centre of the coil to hold the test specimen (*see* Fig. 1).

4.1.6 *Cotton Yarn or Cotton Canvas*

Cotton Yarn – grey, unboiled, 15 tex × 2 (or $40^S/2$) combed, long staple.

Cotton canvas – grey, unboiled, 615 g per m^2.

4.2 Preparation of Test Specimens

4.2.1 From the grey cotton yarn, cut out the required number of bundles, each containing 160 parallel ends, 25 mm in length. In case of canvas, cut out the required number of test specimens of size 25 mm × 25 mm with the help of a die. Alternatively, prepare test specimens of 25 mm diameter.

NOTES

1 The cotton yarns may be tied by single thread of the same quality (*see* **4.1.6**) to form the bundle

2 The square pieces may be cut with sharp pair of scissors. Precautions should be taken that there are not frayed ends.

4.3 Procedure

4.3.1 Take a 600-ml beaker or glass jar. Pour 500 ml of caustic soda solution at 27 ± 2°C. Pipette out 3.75 ml of one of the wetting agents (*see* Note 1) under test. Stir the contents until the wetting agent is dissolved completely in caustic soda solution (*see* Note 2). Allow the solution to stand until all air bubbles have risen to the surface.

NOTES

1 It is presumed that the mercerizing wetting agents are mostly liquids.

2 It is often better to mix the wetting agent thoroughly with small volume of the caustic soda solution before adding this to the bulk of

the mercerizing solution. It should be particularly noticed whether the wetting agent remains well dispersed or dissolved because separation of an immiscible layer on the surface would entirely vitiate the results and give false values.

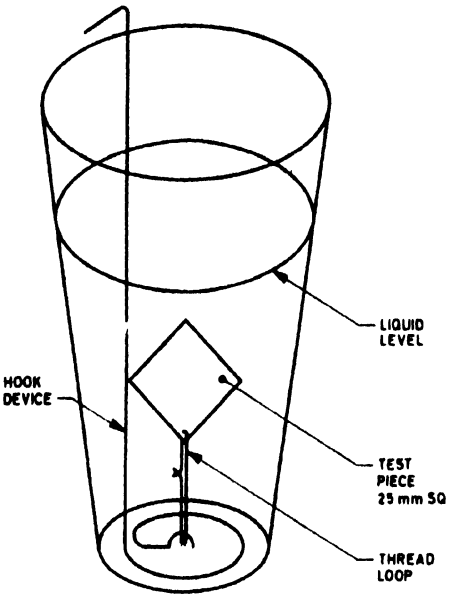


FIG. 1 APPARATUS FOR DETERMINATION OF WETTING TIME

4.4 In case of yarn drop one bundle carefully on the surface of caustic soda solution. Start the stop-watch and note the time required for complete wetting of all the ends.

And in case of canvas attach a loop of thick sewing thread about 100 mm in perimeter to one corner of the test specimen. Attach the specimen through the loop to the wire holder. Hold the wire holder with one hand and the test specimen with the other. Immerse the test specimen in caustic soda solution gently such that the specimen remains upright in the solution and the thread of the loop is also straight (*see* Fig.1). Start the stop-watch. Note the time required for the specimen to sink as indicated by limping of the thread.

4.5 Repeat the test (*see* **4.4**) for four times for the same concentration of the wetting agent and calculate the average sinking time.

4.6 Repeat the test (*see* **4.4** and **4.5**) with different concentrations of wetting agents, say, by adding 5.00 ml and 6.25 ml each time instead of 3.75 ml of wetting agent in caustic soda solution, and calculate the average sinking time for each concentration separately.

NOTE — If the mercerizing agent to be tested is too efficient or too inefficient to obtain comparison within the range of the volumes already employed then either smaller (1.25 ml, 2.50 ml) or larger (10.00 ml, 12.50 ml) volumes of the product should be tested.

4.7 Plot a graph showing the average sinking time against the corresponding concentrations of wetting agents in ml per 500 ml of caustic soda solution. Similarly, plot the graphs for the other wetting agents under test on the same graph paper.

4.8 From the graphs obtained as in **4.7**, determine the wetting time for each wetting agent under test for specific concentration, say, 5.00 ml of wetting agent.

4.9 Compare the results to determine the relative wetting power of the wetting agents under test bearing in mind that lesser the wetting time, the higher is the efficiency of the wetting agent.

5 SECOND METHOD

5.1 Apparatus and Materials

5.1.1 A 50-ml graduated burette in 0.1 ml with a two way stopcock and a side arm – the side arm being connected to a reservoir.

5.1.2 *A Stop-Watch*

To read correct to one-tenth of a second.

5.1.3 *Cotton Yarn*

Grey, unboiled 15 tex × 2 (or $40^s/2$) combed, long staple cotton.

5.2 Procedure

5.2.1 To one end of the cotton yarn tie a one-gram weight. Adjust the yarn in such a way that the knot tied on the weight coincides with the 50-ml mark of the burette. The other end of the yarn is fitted above the burette in such a way that the yarn is in the central position (*see* Fig. 2). Prepare separately solutions containing four different concentrations of the wetting agent under test. Draw into the burette 50 ml of the solution from the reservoir and start the stop-watch when the level of the solution reaches the zero mark. Observe the contraction in one minute (*see* Notes under **4.3.1**).

5.2.2 Repeat the test for nine times for the same concentration of wetting agent in the solution. Calculate the average of the ten determinations.

5.2.3 Calculate percentage contraction as follows:

$$\frac{\text{Difference in burette reading}}{50} \times 100$$

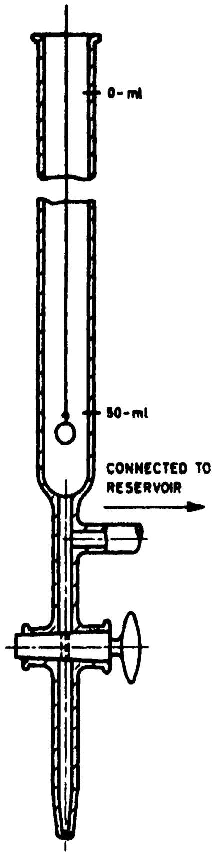


Fig. 2 Apparatus for Determination of Yarn Contractions

5.3 Similarly, determine the percentage contraction for other concentrations of the wetting agent.

5.4 Similarly, determine the percentage contractions for the other wetting agents at the same four concentration (*see* Note under **4.6**).

5.5 Plot a graph showing the average percentage contraction against concentration of wetting agent. Similarly, plot the graphs for the other wetting agents under test on the same graph paper.

5.6 From the graphs obtained in **5.5**, determine the percentage contraction for each wetting agent under test for specific concentration.

5.7 Compare the results to determine the relative wetting power of the wetting agents under test bearing in mind that higher the percentage contraction, higher is the efficiency of the wetting agent.

6 REPORT

The report shall include the following information:

a) Materials tested;
b) Method used; and
c) Relative efficiency.

METHODS OF TEST FOR COATED AND TREATED FABRICS

PART 1 DETERMINATION OF ROLL CHARACTERISTICS

[*Source* : **IS 7016 (Part 1) : 1982**]

Coated and treated fabrics are normally sold in the roll form. It, therefore, becomes essential to find out the correct length, width and thickness of the rolls of fabric before accepting the supply. Further, the mass per unit area of the coated and treated fabric, base fabric and of the coating are important requirements of contract for such fabrics. Determination of all these characteristics are collectively called the roll characteristics.

1 SCOPE

It describes the methods for determining the length, width, net mass, mass per unit area, and thickness of rolls of coated and treated fabrics, with the exception of knitted type fabrics.

NOTE — It should be noted that the roll cannot normally be conditioned in a standard atmosphere and, therefore, the results may be influenced by variation of moisture due to changes in atmospheric conditions.

2 DETERMINATION OF THE LENGTH OF A ROLL

2.1 General Method

2.1.1 *Apparatus*

Flat table, not less than 5 m long, and at least as wide as the roll to be tested. Both longitudinal edges of the table should be marked off in 1 m lengths, at least one of these lengths being subdivided into 10 mm divisions.

2.1.2 *Procedure*

Trim the cut end of roll, if necessary, so that it is at right angles to the warp (longitudinal) direction of the roll, such trimming being confined to the minimum which is necessary to effect this. With the cut end of the roll aligned with the zero mark on the table, unroll the material along the table so that no tension is introduced. On reaching the limit of the table, mark the back of the roll by some suitable method on both edges to coincide with a known division of length. Reroll the portion that has been measured. Lay out, free from tension, a further portion of the unmeasured length and measure from the marked edges, as before. Repeat this process until the end of the roll is reached, trimming this, if necessary, as before. Measure the final length to the nearest 50 mm.

2.1.3 *Expression or Results*

Report the length of the roll, in metres, as the sum of all the readings, adjusted to the nearest 50 mm.

2.2 Drum Method

2.2.1 *Procedure*

Run the coated fabric over a measuring drum with just enough uniform tension to keep it running flat and true. Determine the length from the dial or counter on the drum. Report the length of the roll in metres, adjusted to the nearest 50 mm.

3 DETERMINATION OF THE WIDTH OF A ROLL

3.1 Apparatus

3.1.1 *Flat Table* - not less than 2 m long, and at least 50 mm wider than the width of the roll to be tested.

3.1.2 *Steel Scale* – length shall be greater than the width of the roll to be measured, graduated in centimetres and millimetres.

3.2 Procedure

Unroll the material along the table so that it is laid out smoothly without tension in either direction. In case of fabrics coated on one side, the coated side shall be kept upwards. Record to the nearest 5 mm at least five different measurements of width uniformly distributed along the full length of the roll or piece.

3.3 Expression of Results

Calculate the mean of the recorded widths adjusted to nearest 5 mm and report the value obtained as the average usable width. Report also the minimum usable width recorded.

4 DETERMINATION OF THE NET MASS AND MASS PER UNIT AREA OF ROLL OR SAMPLE

4.1 Determination of the Net Mass Per Unit Area of a Roll

4.1.1 *Apparatus*

Weighing device, with a calibrated scale, accurate at full scale deflection to 0.10 percent.

4.1.2 *Procedure*

Place the roll of material centrally on the pan or other supporting arrangement of the weighing device. Ensure that the roll and its support are free of contact with other bodies. Determine and record the gross mass. Determine and record the mass of the tube or former upon which the material has been rolled, and deduct this from the gross mass. Record the value thus obtained as the net mass. Determine the length and width of the roll in accordance with the procedure given in 2 and 3, and calculate the mass per unit area in grams per square metre to the nearest 5 g/m^2.

4.1.3 *Expression of Results*

The net mass should be expressed in kilograms to the nearest 0.10 kg. The mass per unit area should be expressed in grams per square metre to the nearest 5 g/m^2.

4.2 Determination of the Mass Per Unit Area of a Sample

4.2.1 *Test Piece*

The test piece shall be square, rectangular or circular in form, and have an area of 10 000 ± 100 mm^2.

4.2.2 *Procedure*

4.2.2.1 Cut from the sample three test pieces, one from the centre, and the other two symmetrical with the first, in such a manner that their external edge is between 50 and 150 mm from the selvedge of the sample taken along a line which makes an angle of 45° with the length of the roll. Designate these test pieces A, B and C respectively.

4.2.2.2 *Conditioning*

Condition the test pieces at 27 ± 2°C and 65 ± 2 percent relative humidity for 48 hours prior to testing. Subject to agreement between the purchaser and the supplier, the conditioning time may be curtailed to 24 hours. For all test purposes, the minimum time between vulcanization or curing and testing shall be 16 hours. Whenever possible, the time between vulcanization or curing and testing should not exceed three months. In other cases, tests, shall be made withing two months of the date of receipt by the customer of the product.

4.2.2.3 Weigh the test pieces to the nearest 0.005 g, and calculate the mass per unit area in grams per square metre.

4.2.3 *Expression of Results*

The mass per unit area should be expressed as the average of the calculated values in grams per square metre, adjusted to nearest 5g/m^2.

NOTE — The procedure given in **4.2.2** is intended for use when a small sample is sent to the laboratory for test The result is considered applicable to the sample, but not to the piece or lot of goods from which the sample was taken, unless the number of samples and methods are agreed by those concerned. If this is done, each sample should be tested in accordance with the procedure given in **4.2.2** and the results averaged to obtain the average mass per unit area in grams per square metre.

4.3 Determination of the Mass Per Unit Area of the Base Fabric

4.3.1 *Apparatus*

4.3.1.1 *Balance* -- accurate to 0.005 g.

4.3.1.2 *Flask* - 500 ml capacity, fitted with a reflux condenser.

4.3.1.3 *Water-bath*

4.3.1.4 *Oven* with natural air circulation.

4.3.2 *Test Piece* - The test piece shall be a square or rectangle, having an area of 10 000 ± 100 mm^2.

4.3.3 *Procedure*

4.3.3.1 Cut from the sample three test pieces, one from the centre, and the other two, symmetrical with the first, in such a manner that their external edge is between 50 and 150 mm from the selvedge of the sample taken along a line which makes an angle of 45° with the length of the roll. Designate these test pieces, A, B and C respectively. Immerse each test piece separately in 150 ml of an appropriate solvent or swelling agent. Decant and remove where possible the bulk of the coating from the base fabric. In case extraction is not sufficient, refluxing for 30 minutes may be done. Immerse again for 30 minutes, using fresh solvent,and decant. Thereafter, immerse the fabric and any loose threads in 150 ml of solvent, with occasional agitation for 30 minutes at room temperature. Remove the stripped test pieces, together with any loose threads, from the solvent and wash them in 100 ml of acetone. Dry the test pieces for one hour at a temperature of approximately 100°C.

4.3.3.2 Condition the stripped test pieces for 24 hours at 27 ± 2°C and 65 ± 2 percent relative humidity, and weigh to the nearest 0.005 g.

4.3.3.3 Wash the stripped test pieces with a further quantity of the appropriate solvent in the manner indicated, wash in acetone, dry and condition and weigh them, as before. If the second weighing differs from the first by more than 1 percent, repeat the solvent treatment until the difference is less than 1 percent. Use the final mass for calculating the mass per unit area of the fabric.

4.3.4 *Expression of Results*

The mass per unit area of the fabric shall be expressed as the mean value obtained from the three results in grams per square metre to the nearest 5 g/m^2.

NOTES

1 The method is not valid for fabrics which are soluble in the solvent used for the test.

2 The mass of the fabric after removing the coating may be different from that of the original fabric.

4.4 Determination of the Mass Per Unit Area of the Coating

4.4.1 *Procedure*

It is expedient to consider the mass per unit area of the coating as the difference between the mass per unit area of the coated fabric and the mass per unit area of the base fabric. From the mass per unit area of the coated fabric (determined according to **4.2**) subtract the mass per unit area of the base fabric for the corresponding test piece (determined according to **4.3**).

4.4.2 *Expression of Results*

The mass per unit area of the coating shall be expressed in grams per square metre as the mean of the three values found in acordance with the procedure given in **4.4.1**.

5 DETERMINATION OF THICKNESS

5.1 Apparatus

5.1.1 *Gauge*

The gauge shall be of dead weight type, equipped with a dial graduated to read directly to 0.02 mm. The presser foot should be circular having a diameter of 9.5 ± 0.02mm or 50 ± 0.05 mm. The presser foot and connected moving parts shall be loaded to give the pressure according to the category of articles being measured. The presser foot and anvil surfaces shall be plane to within 0.002 mm, and parallel to one another to within 0.002 mm. The gauge shall be calibrated for the actual load exerted by the presser foot by means of any device so arranged to measure the total force exerted by the presser foot at the several gauge readings or presser foot levels selected for calibration. The presser foot shall be brought to each calibration level from a higher one:

	Pressure
a) Ordinary articles	24 KN/m^2*
b) Articles sensitive to pressure	10 KN/m^2*

5.2 Procedure

5.2.1 Measure the thickness on an oblique line drawn at an angle of 45° to the length of the roll preferably at a distance of about 1 m from the end of the roll. On this line, make five evenly distributed measurements, the first being taken at a position between 50 and 150 mm from the selvedge.

5.2.2 Place the coated fabric on the anvil of the gauge, smoothen it but without tension. Lower the presser foot into the material (without impact), allow it to rest for 10, seconds and observe and record the reading of the dial.

5.3 Expression of Results

Express the results in millimetres. The mean linear thickness in millimetres is the arithmatic mean of the five measured values on the same oblique line.

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* 1 kgf/Cm^2 = 98.07 KN/m^2.

METHODS OF TEST FOR COATED AND TREATED FABRICS

PART 2 DETERMINATION OF BREAKING STRENGTH AND EXTENSION AT BREAK

[*Source* : **IS 7016 (Part 2) : 1981**]

The strength value determined when a specimen of textile fabric or coated fabric is tested to breaking is not a fixed quantity; it depends on the width and length of the specimen, on its moisture content, temperature and on the speed at which the breaking load is reached. In addition to real changes in specimen strength, errors in observed value can occur through errors of the testing machine and its operation. The testing machine is accurate under static or slow moving conditions, but not so in the case of very rapidly applied load. Failure to grip the whole width of specimens leads to partial slip and to less than the fair estimate of strength. At present, therefore, the concept of breaking strength of a coated and treated fabric is an empirical approximation under one-way stretch conditions to the biaxial strength shown by the fabric in actual service. For the sake of general agreement on quality assessment it has become necessary to standardize most of the conditions under which breaking strength of base fabrics should be tested, and as far as possible similar conditions are desirable for coated fabrics.

1 SCOPE

1.1 It covers methods of test for determination of breaking strength and extension at break using the following types of machines:

a) Constant rate of load,
b) Constant rate of traverse, and
c) Constant rate of specimen extension.

1.1.1 This method is not suitable for use with products of which base cloth is of mesh constructrion or with knit fabrics.

2 APPARATUS

2.1 Tensile Testing Machine

All tensile machines shall be provided with means for indicating or preferably for recording both the maximum load applied to the specimen in stretching it to rupture and the corresponding extension of the specimen. Alternatively any other means to measure extension may be used. Under the conditions of use, the error of the indicated or recorded maximum load at any point in the range in which the machine is used shall not exceed ± 1 percent of the load, and the error of the indicated or recorded maximum jaw separation shall not exceed 1 mm. The central points of the two jaws of the machine shall be in the line of pull, the front edges shall be perpendicular to the line of pull, and their clamping faces shall be in the same plant. The jaws shall be capable of holding the specimen without allowing it to slip, shall be so designed that they do not cut or otherwise weaken the specimen, and shall be wider than the test specimen. The faces of the jaws should preferably be smooth and flat, but when the specimens cannot be satisfactorily held with flat-faced jaws even with packing, engraved or corrugated jaws may be used.

NOTE Pieces of felt approximately 3 mm thick have been found to be suitable for packing, but the choice of type of jaws and packing should be that combination which gives the highest breaking load and does not cause an undue number of breaks in close proximity to the edges of the jaws Suitable packing materials for use with either smooth or corrugated jaws include paper, felt, leather, plastics or rubber sheets

2.1.1 *Constant-Rate-of-Load Machines*

After the first 10 seconds of the test, the average rate of increase of load in any two seconds interval shall not differ by more than 25 percent from the average rate of increase of load over the whole period of the test.

The machine shall apply the required load within 60 + 10 seconds. The required load shall be the specified minimum breaking load or, when the minimum breaking load is not specified, the average breaking load as estimated from preliminary experiments.

2.1.2 *Constant-Rate-or-Traverse Machines*

After the first five seconds of the test, the average rate of traverse of the pulling jaw in any two seconds interval shall not differ by more than 5 percent from the average rate of traverse over the whole period of the test. The rate of traverse of the pulling jaw shall be 100 ± 10 mm/min.

2.1.3 *Constant-Rate-of-Extension Machines*

For machines in which the rate of separation of the clamps is independent of the extensibility of material under test, the rate of traverse of the pulling jaw shall be such that rupture is reached in 60 ± 10 seconds.

3 TIME LAPSE BETWEEN MANUFACTURE AND TESTING

3.1 For all test purposes the minimum time between manufacture and testing shall be 16 hours, in order to ensure that the material attains dimensional stability due to stress relaxation.

3.2 In order to bind the user and supplier to a stipulated time for carrying out conformity test for supplied material, the following shall apply.

3.2.1 For non product test separate test piece is required for testing. Therefore, the maximum time between the manufacture and testing shall be eight weeks and for evaluation intended to be comparable, the tests as far as possible, should be carried out after the same time interval.

3.2.2 For product test, whenever possible the time between manufacture and testing should not exceed six months. In other cases tests shall be made within four months of the date of the receipt of the product by the customer.

4 TEST PIECES

4.1 From the sample, cut test pieces of coated and treated fabric 50 ± 0.5 mm wide and of convenient length so as to permit a free length of 200 mm between the jaws. Five test pieces shall be cut with the length parallel to the warp threads and five test pieces with the length parallel to the weft thread. In case of difficulty, establish the direction of the warp thread by tearing and then cut test pieces parallel to this direction. Select test pieces fairly evenly spaced over the full usable length and width of the sample avoiding the selvedge so that no two test pieces contain the same warp threads or weft threads as the case may be.

5 CONDITIONING

5.1 Conditioning

Condition the test pieces at 27 ± 2°C and 65 ± 2 percent relative humidity for 48 hours prior to testing.

6 PROCEDURE

6.1 Set the jaws of the testing machine 200 ± 1 mm apart. Clamp a test piece centrally in the jaws so that its longitudinal centre line passes through the centred points of the front edges of the grips. Apply the appropriate pre-tension from the following values:

	Recommended Pre-tension
a) For fabrics up to and including 200 g/m^2	2 N
b) For fabrics over 200 and up to and including 500 g/m^2	5N
c) For fabrics over 500 g/m^2	10 N

6.2 Engage any device for reading the breaking load and elongation, put the moving clamp in motion and extend the test piece to the point of rupture under the conditions appropriate for the type of machine being used as specified in 3. Repeat the procedure for each test piece.

NOTE — If any test piece breaks within 10 mm of line of contact of either of the jaws, record the result; but if it is found to have broken at a load less than 75 percent of the average of the remainder of the specimens do not use it in calculating the breaking load. Test another specimen.

7 EXPRESSION OF RESULTS

7.1 Breaking Load

Calculate the mean of the five results for breaking load for each direction and report the values obtained as breaking load in N/50 mm width stating the method used.

7.2 Extension at Break

Calculate the mean of the five results in each direction and express this as a percentage of the initial gauge length as follows:

$$\text{Extension at break, percent} = \frac{\text{Increase in gauge length}}{\text{Original gauge length}} \times 100$$

METHODS OF TEST FOR COATED AND TREATED FABRICS

PART 3 DETERMINATION OF TEAR STRENGTH

[*Source* : **IS 7016 (Part 3) : 1981**]

This test method is designed to determine the tear strength of fabrics coated with rubber or plastics.

1 SCOPE

1.1 It prescribes three methods for the determination of the tear resistance of fabrics coated with rubber or plastics. The methods A1, A2, and B, do not give the same results.

1.1.1 The methods are applicable to coated fabrics in which the constituents of the backing fabric perpendicular to the direction of tearing are broken; they are not applicable to fabrics with cellular backing or a meshed cloth backing in which the tear pattern is complex, and are only of limited value for coated fabrics employing knitted-base fabrics.

2 PRINCIPLE

In methods A1 and A2, force is applied to extend steadily a cut in the test piece. In method B, a sudden force is applied to the test piece with a cut in it.

3 SAMPLING

3.1 The samples shall be cut in such a way as to be as representative as possible of the whole piece being examined. The test pieces shall be selected in such a way that their edges are situated at a minimum distance of 0.10 m from the longitudinal edge; they shall not be taken from less than 1 m from the ends of the piece.

3.1.1 For the test for tearing in the transverse direction (that is tearing longitudinal threads), the test pieces shall be selected so that their width is parallel to the longitudinal edge of the coated fabric.

3.1.2 For the test for tearing in the longitudinal direction (that is tearing transverse threads), the test pieces shall be selected so that their width is perpendicular to the longitudinal edge of the coated fabric.

4 NUMBER OF TEST PIECES

4.1 For each series of tests, 10 test pieces shall be selected, 5 in the longitudinal direction and 5 in the transverse direction of the sample piece. The same thread of cloth in the direction to be tested shall not appear in more than one test piece.

5 TIME LAPSE BETWEEN MANUFACTURE AND TESTING

5.1 For all test purposes, the minimum time between manufacture and tesing shall be 16 hours, in order to ensure that the material attains dimensional stability due to stress relaxation.

5.2 In order to bind the user and supplier to a stipulated time for carrying out conformity test for supplied material, the following shall apply.

5.2.1 For non-product test, separate test pieces are required for testing. Therefore, the maximum time between manufacture and testing shall be 6 weeks and for the evaluation to be comparable the tests, as far as possible, shall be carried out after the same time interval.

5.2.2 For product test, whenever possible the time between manufacture and testing shall not exceed 6 months. In other cases, tests shall be made within 4 months of the date of the receipt of the product by the customer.

6 CONDITIONING OF TEST PIECES

6.1 The test pieces shall be conditioned immediately before testing for a minimum of 48 hours at 27 ± 2°C and 65 ± 2 percent relative humidity.

6.2 If it is required to determine the properties of wet material, the test pieces shall be immersed in distilled water containing 1 percent (*v/v*) ethanol for 24 hours at 27 ± 2°C. The test pieces shall be cut prior to this immersion. Immediately after removal of the test pieces from water, they shall be blotted between two sheets of absorbent paper and tested at once.

7 TEST METHODS

7.1 Method A — Constant Rate of Tear

7.1.1 The test machine shall be power-driven and shall be equipped with a suitable dynamometer. It shall be capable of maintaining, during the test, a substantially constant rate of traverse within the range 1.7 ± 0.17 mm/s or 5.0 ± 0.2 mm/s and of recording the force autographically. An inertialess dynamometer (for example of electronic or optical type) shall preferably be used.

NOTE — Pendulum type inertia dynamometres may in fact give different results because of the effects of friction and inertia When the use of an inertia dynamometer is unavoidable, information may be obtained on the tear resistance in the following way: the capacity of the machine, or the measuring scale selected when a variable-range machine is involved shall be such that the separation force reading is between 15 and 85 percent of the rated capacity.

7.1.1.1 The accuracy of the machine shall be such that the error in the force measurement as shown and recorded shall not exceed 2 percent of the force or 0.4 percent of the maximum of the scale, whichever is the smaller. The jaws of the machine shall be wider than the test piece and, in any case, not less than 75 mm wide.

7.1.1.2 All edges that might cause a cutting action shall be rounded to a radius of not more than 0.4 mm. The pressure between the gripping surfaces, sufficient to clamp the test piece firmly before the testing load is applied and to prevent slippage during the progress of the test, shall be attained by means of any suitably constructed mechanical device operating on the movable member of the clamp.

7.1.2 *Method A1 – Test Using Three-Tongued Test Piece* – Double Tear.

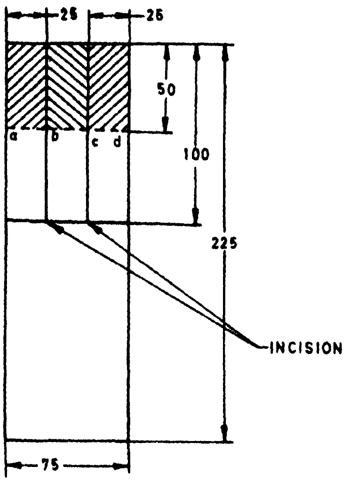
7.1.2.1 *Test piece*

The test piece (*see* Fig.1) shall be rectangular, 225mm long by 75 mm wide. Two longitudinal slits 100 mm in length shall be made in it to form 3 tongues, 25 ± 0.5 mm wide.

7.1.2.2 *Procedure*

Adjust the test machine to give the required rate of jaw traverse and select an appropriate load capacity range. Engage and zero the autographic recorder. Place the middle tongue of the test piece in the fixed jaw so that the line bc (*see* Fig.1) is just visible. Maintain the distance between the two tongues at 25 mm. Set up test pieces with the respective axes of the backing fabric parallel and perpendicular to the direction of application of force.

Start the test machine at the specified rate of traverse and continue the tearing until the test piece is completely torn.



All dimensions in millimetres

FIG. 1 THREE-TONGUED TEST PIECE

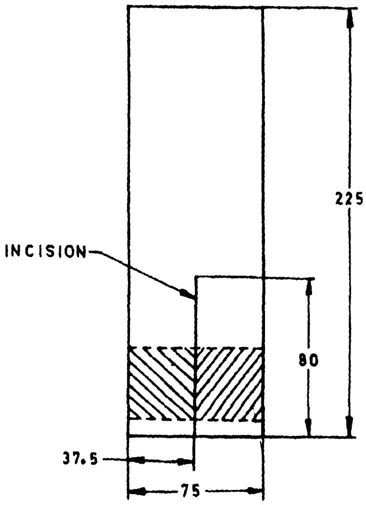
7.1.2.3 *Expression of results*

From the trace obtained on the recorder, determine the median of the 5 highest forces on the central 50 percent. Report the result as the median value for 5 test pieces.

7.1.3 *Method A2 - Test Using Trouser-Shaped Test Piece* – Single Tear

7.1.3.1 *Test piece*

The test piece (*see* Fig. 2) shall be a rectangular strip 225 mm long by 75 ± 0.5 mm wide. A longitudinal slit, 80 mm in length, shall be made in it beginning from the middle of the width.



All dimensions in millimetres.

FIG. 2 TROUSER-SHAPED TEST PIECE

7.1.3.2 *Procedure*

Adjust the test machine to give the required rate of jaw traverse and select an appropriate load capacity range. Engage and zero the autographic recorder. Place the test piece symmetrically in the jaws, with one tongue in each of the jaws and the uncut end of the test piece remaining free. Take care to ensure that each tongue is fixed in a jaw, so that the beginning of the tear is parallel to the direction in which the tearing force is applied.

Start the test machine at the specified rate of traverse and continue the tearing until the test piece is completely torn.

7.1.3.3 *Expression of results*

From the trace obtained on the recorder, determine the median of the 5 highest forces on the central 50 percent. Report the result as the median value for 5 test pieces.

7.2 Method B – Tear Falling Pendulum

7.2.1 *Apparatus*

The test machine is of the pendulum type – in which the test piece is held between two jaws, one movable and the other fixed. The clamping faces of the jaws shall be in the same plane when the apparatus is in its starting position. The moving jaws are attached to a pendulum which can fall under the influence of gravity.

The apparatus is made up of the following parts:

a) A pendulum comprising a circumferential graduated scale to indicate the energy used to tear the test piece. The test apparatus shall be provided with several interchangeable scales so that the tearing energy is between 15 and 85 percent of the scale maximum. This pendulum may swing freely about a horizontal axis on roller bearings.

b) A movable jaw solid with the pendulum and a fixed jaw solid with the framework. These jaws shall be 2.5 mm apart in order to just permit the passage of the knife. When the pendulum is in its starting position, the clamping faces of the jaws shall be in the same plane perpendicular to the plane of swing of the pendulum. The force of the jaws and the surface state of the clamping faces shall permit the test piece to be held without slipping.

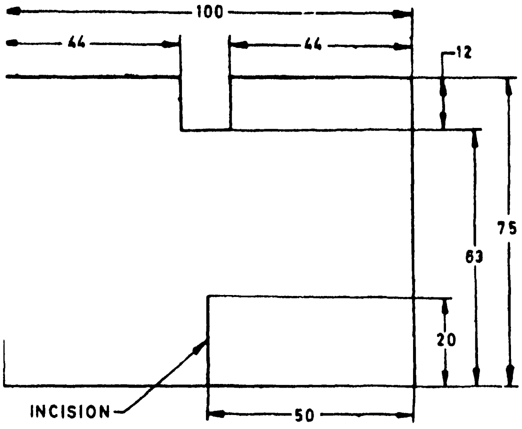
c) A sector release to hold the pendulum in a raised position during the mounting of the test piece and to release the pendulum to tear the test piece.

d) A pointer, driven by the pendulum, and a pointer stop to record the maximum arc of the swing of the pendulum.

e) A knife to begin the tear of the test piece by cutting a slit in it exactly half-way between the two jaws.

7.2.2 *Test Piece*

The test piece (*see* Fig. 3) shall be a rectangle, 100 mm long and 75 ± 0.5 mm wide. In one of the 100 mm sides, there shall be a notch 12 ± 0.5 mm square.



Tolerances on dimensions = ± 0.5
All dimensions in millimetres

FIG. 3 NOTCHED TEST PIECE

7.2.3 *Procedure*

Level the apparatus in a horizontal position. Adjust the pointer so that when the apparatus is operated without a test piece it stops at zero. Repeat this operation several times. Set the pendulum to bring the two jaws to the same alignment. Put the pointer in the starting position. Clamp the test piece in the jaws, so that the long side of the test piece is parallel to the line of the upper edges of the jaws. Using the knife [*see* 7.2.1 (e)], make an incision 20 ± 0.5 mm in the centre of the side opposite the 12 mm square notch. Free the pendulum. When the test piece has been torn, read the scale.

NOTE — The accuracy of the test depends on the length of the material which is not cut.

7.2.4 *Expression of Results*

For each series of test pieces, determine the median of the 5 energy values obtained in the longitudinal direction and in the transverse direction respectively.

8 TEST REPORT

The test report shall include the following particulars:

a) The test method used (that is, A1, A2 or B) and the rate of traverse (method A1 or A2);

b) The individual results obtained on each of the 10 test pieces; and

c) The median values in the longitudinal and transverse directions.

METHODS OF TEST FOR COATED AND TREATED FABRICS

PART 4 DETERMINATION OF RESISTANCE TO DAMAGE BY FLEXING

[*Source* : **IS 7016 (Part 4) : 1987**]

Flex testing provides useful information about the durability of treated fabrics. It is important in accelerated flexing tests to ensure that the specified air temperature is maintained during the test. This may be achieved either by maintaining adequate ventilation around the test pieces or by controlling the air temperature within any closed container in which the test apparatus may be mounted.

Two methods are described here. In the De-Mattia test, a test specimen is folded in three and subjected to repeated bending through an angle of approximately 180°. In the Schildknecht test, the specimens are mounted in the form of a cylinder and, when flexed, assume a concertina shape; a larger area is, therefore, subjected to flexing than in the De-Mattia test and the creases are random as in clothing applications.

Flex testing provides useful information for the ability of coated fabrics to resist the development of cracks or the general mechanical deterioration of the material as a result of a relatively large number of flexes. There is no sharp end-point in a flexing test for a coated fabric and it has not been found possible to define any arbitrary stage in the break down of the coating which will ensure agreement between laboratories using similar machines.

1 SCOPE

It prescribes two methods for determination of resistance to damage by flexing of fabrics coated with rubber or plastics.

2 DE-MATTIA METHOD

2.1 Apparatus

A flex testing machine consisting of pairs of flat grips of each pair being positioned vertically above the other. One of the grips of each pair shall be capable of a reciprocating motion in a vertical plane; the rate of movement of the reciprocating grip being 5.0 ± 0.2 Hz.

Each pair of grips shall be so positioned that they are 70 ± 1 mm apart when in the open position and 12.5 ± 0.5 mm apart when in the closed position.

2.1.1 Suitable machine for this test is the De-Mattia flex tester or equivalent.

2.2 Sampling

The sample shall be cut so that it is as representative as possible of the whole consignment. The test piece shall be taken at least 0.05 m from the selvedge and at least 1 m from the beginning or end of the piece.

2.3 Test Pieces

2.3.1 *Dimensions*

The standard test piece shall consist of a rectangular strip about 125 mm long and 37.5 ± 1 mm wide.

NOTE — By suitable increases in the width of grips, the test pieces size may be increased so as to permit subsequent hydrostatic head tests to be conducted.

2.3.2 *Number*

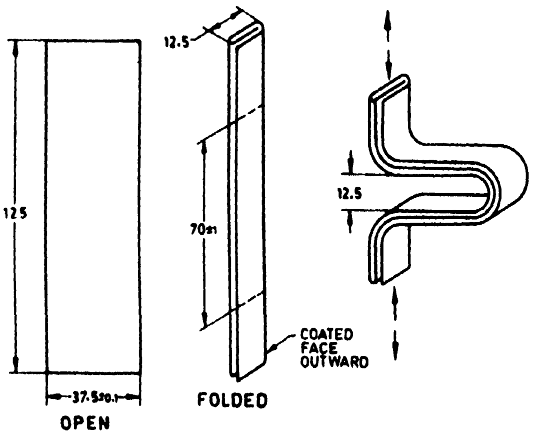
For each series of test, cut six test pieces, three parallel to the longitudinal direction and three parallel to the transverse direction. No two test pieces shall contain the sample threads of the fabric in the direction to be tested.

2.3.3 *Conditioning*

Condition the test pieces at 27 ± 2°C and 65 ± 2 percent relative humidity for 48 hours prior to testing. Subject to agreement between the purchaser and the supplier, the conditioning time may be curtailed to 24 hours. For all test purposes, the minimum time between vulcanization or curing and testing shall be 16 hours. Whenever possible, the time between vulcanization or curing and testing should not exceed three months. In other cases, tests shall be made within two months of the date of receipt of the product by the customer.

2.4 Procedure

2.4.1 Fold each test piece twice with the coating to be tested out-wards along the lines 12.5 mm from each of the longer edges and to a width of 12.5 mm. Mount the folded test piece between a pair of grips of the flexing machine so that the coating on the centre section should be subjected to an outward fold. Mount the test piece with the grips in open position, so that after fixing it is neither under tension nor loose. A bench mark on the specimen may be used for ensuring the proper fixing of the specimen in the grips. Move the grips together by hand and guide each test piece into a fold at approximately the mid-point as shown in Fig. 1.



All dimensions in millimetres.

FIG. 1 DE-MATTIA FLEX TESTING (DIAGRAMMATIC)

2.4.2 Set the apparatus in motion and stop it after the specified number of cycles or, if the point of failure or breakdown of the coated fabric is to be determined, stop the apparatus at geometrically spaced intervals to enable examination of the test piece. Move the grips by hand to the closed position and examine the test piece under X 5 magnification for cracks in the coating. Failure in any test piece shall be deemed to have occurred when one or more cracks (not less than 2.0 mm long and extending through the coating to the base cloth) may be detected. Terminate flexing either at the specified number of cycles or at the first inspection at which a total of three or more test pieces have been found to have failed. Assess the flexing damage in accordance with **2.5**.

NOTE — Because of the low reproducibility of the test, frequent examination is unnecessary. A suggested series of intervals is given below together with the geometric mean figures.

Examination intervals (thousands)	31.5, 50, 80, 125, 200, 315, 500, 800, 1 250
Mean (thousands)	40, 63, 100, 160, 250, 400, 630, 1 000

2.5 Examination and Assessment of Flexing Damage

2.5.1 *Assessment of Flex Crack Resistance*

Assess the overall appearance, taking into account all visible factors such as wrinkling, cracking, flaking and discolouration. Compare the flexed test specimens with the unflexed material and grade the flexed material according to the following four part scale relative to the unflexed material, without magnification, as deterioration in appearance:

0. None
1. Slight
2. Moderate
3. Severe

NOTE — Intermediate assessments are acceptable.

2.5.1.1 *Description of damage*

Describe the type of damage, if any, which is present.

2.5.2 *Grade, Depth, Number and Length of Cracking*

2.5.2.1 *Grade of cracking*

Using a × 5 lens or, preferably a × 5 stereo microscope, examine the test specimen closely and report the depth, number and length of cracks, if any, in accordance with the following three-part scale:

Part 1 *Depth of Cracking* – Grade the depth of cracking according to the following :
Nil — no cracking;

A – Surface or finish crack, nor exposing the cellular or middle layer, or in the case of solid single layer coatings, cracking only extends to the top 20 percent of the coating thickness;

B – Cracking into but not right through the middle layer, or, in the case of single layer coatings, does not expose the base fabric;

C – Cracking through to the base fabric; and

D – Cracking right through the material.

Part 2 *Number of Cracks* – Record the number of cracks of lowest grade representing the worst degree of cracking. If there are more than 10, simple report 'Over 10'.

Part 3 *Length of Cracks* – Record the length in mm of the longest crack of the lowest grade representing the worst degree of cracking.

2.5.3 *Delamination*

In order to assess whether delamination has occurred to any appreciable degree, either test specifically for significant changes in coating adhesion or for changes in performance in terms of abrasion or snag resistance, wicking or hydrostatic head resistance. Alternatively, cut through the whole thickness of the material at a point where its occurrence is suspected to reveal any delamination.

NOTES

1 Delamination may not be apparent or visible but nevertheless still renders the coated fabric more susceptible to abrasion damage, snagging and wicking and may also reduce the hydrostatic head resistance.

2 These are optional additional tests and do not relate to the flexing test, save as a means of assessing the effect of flexing on the coated fabric.

2.6 Expression of Results

2.6.1 Where relevant, calculate the geometric mean and the geometric ratio of the number of flexes at final inspection, and the number of flexes at the preceding inspection. Calculate the geometric mean to two significant figures and report this as the flex index.

NOTE — Where the test is used as a pass/fail test there is only one inspection, namely at the specified number of cycles. The calculation of a geometric mean then becomes irrelevant.

2.7 Test Report

The following information shall be reported:

a) Reference of the sample;

b) Conditioning method and time of exposure;

c) Conditions in which the tests have been conducted;

d) Method of test;

e) Number of flexes at final inspection and the geometric ratio, where relevant; and

f) Flex index, where relevant.

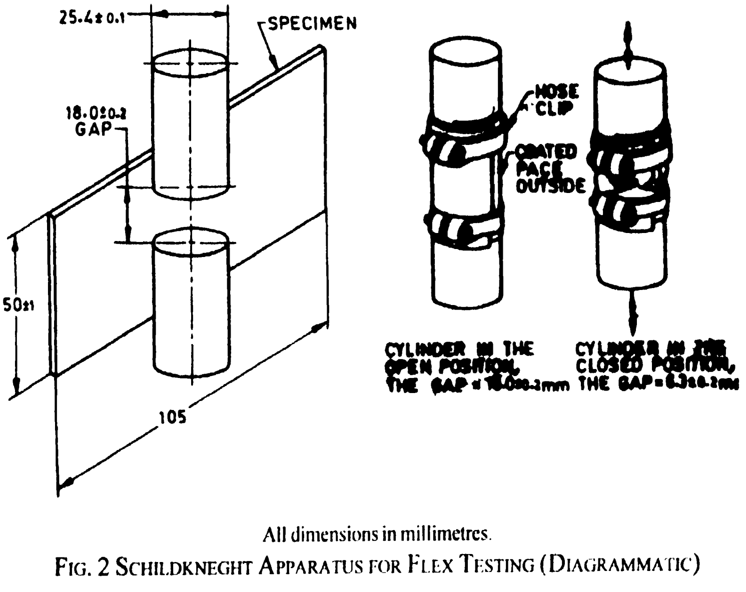
3 SCHILDKNECHT MACHINE METHOD

3.1 Apparatus

A machine consisting of a pair of metal cylinders so that the axis of each pair are in the same straight line. The cylinders are 25.4 ± 0.1 mm in external diameter and one cylinder of each pair is capable of a reciprocating motion along its axis at the rate of 8.5 ± 0.2 Hz. When a pair of cylinders is in the open position, the ends of each pair are 18.0 ± 0.2 mm apart, and when in the closed position they are 6.3 ± 0.2 mm apart. Hose clips to attach the test pieces to the cylinders. Schematic diagram of the Schildknecht machine is shown in Fig. 2.

3.2 Sampling

The sample shall be cut so that it is as representative as possible of the whole consignment. The test piece shall


25.4 ± 0.1
SPECIMEN
18.0 ± 0.2
GAP
50 ± 1
105
HOSE CLIP
COATED FACE OUTSIDE
CYLINDER IN THE OPEN POSITION, THE GAP = 18.0 ± 0.2 mm
CYLINDER IN THE CLOSED POSITION, THE GAP = 6.3 ± 0.2 mm

All dimensions in millimetres.

FIG. 2 SCHILDKNEGHT APPARATUS FOR FLEX TESTING (DIAGRAMMATIC)

be taken at least 0.05 mm from the selvedge and at least 1 m from the beginning or end of the piece.

3.3 Test Piece

3.3.1 *Dimensions*

The standard test piece shall consist of a rectangular strip 105 mm long and 50 ± 1 mm wide.

NOTE — When hydrostatic head tests are to be subsequently conducted, the size of the test piece used for flexing shall be 105 mm × 65 mm and mounted on the metal cylinder in accordance with the figure.

3.3.2 *Number*

For each series of tests cut six test pieces, three parallel to the longitudinal direction, and three parallel to the transverse direction. No two test pieces shall contain the same threads of the fabric in the direction to be tested.

3.3.3 *Conditioning*

Condition the test pieces at 27 ± 2°C and 65 ± 2 percent relative humidity for 48 hours prior to testing. Subject to agreement between the purchaser and the supplier, the conditioning time may be curtailed to 24 hours. For all test purpose, the minimum time between vulcanization or curing and testing shall be 16 hours. Whenever possible, the time between vulcanization or curing and testing should not exceed three months. In other cases, tests shall be made within two months of the date of receipt of the products by the customer.

3.4 Procedure

Mount each test piece with coating to be tested out-wards around two opposing cylinders that are in the fully open position with the length of the test piece around the circumference of the cylinders. Secure the test pieces into position on each cylinder by means of a hose clip in such a manner that the edge cylinder and hose clip are coincident. Set the apparatus in motion and stop it after the specified number of cycles or, if the point of failure or breakdown of the coated fabric is to be determined, stop the apparatus at geometrically spaced intervals to enable examination of the test piece. Move the grips by hand to the closed position and examine the test pieces under × 5 magnification for cracks in the coating. Failure in any test piece shall be deemed to have occurred when one or more cracks (not less than 2.0 mm long and extending through the coating to the base cloth) can be detected. Terminate flexing either at the specified number of cycles or at the first inspection at which a total of three or more test pieces have been found to have failed. Assess the flexing damage in accordance with **3.5**.

NOTE — Because of the low reproducibility of the test, frequent examination is unnecessary. A suggested series of intervals is given below, together with the geometric mean figures..

Examine intervals (thousands)	31.5, 50, 80, 125, 200, 315, 500, 800, 1 250
Mean (thousands)	40, 63, 100, 160, 250, 400, 630, 1 000

3.5 Expression of Results

Where relevant, calculate the geometric mean and the geometric ratio of the number of flexes at final inspection, and the number of flexes at the preceding inspection. Calculate the geometric mean to two significant figures and report this as the flex index.

NOTE — Where the test is used as a pass/fail test there is only one inspection, namely at the specified number of cycles. The calculation of a geometric mean then becomes irrelevant.

3.6 Test Report

The following information shall be reported:

a) Reference of the sample;
b) Conditioning method and time of exposure;
c) Conditions in which the tests have been conducted;
d) Method of test;
e) Number of flexes at final inspection and the geometric ratio, where relevant; and
f) Flex index, where relevant.

METHODS OF TEST FOR COATED AND TREATED FABRICS

PART 5 DETERMINATION OF COATING ADHESION STRENGTH

[*Source* : IS 7016 (Part 5) : 1987]

1 SCOPE

It describes method of test for determination of coating adhesion strength of coated and treated fabrics in which there is a distinct coating either on one side or both sides.

2 APPARATUS

2.1 Tensile Testing Machine

The tensile testing machine shall be provided with means for indicating or preferably for recording the maximum load applied to the specimen in stretching. Under the conditions of use, the error of the indicated or recorded maximum load at any point in the range in which the machine is used shall not exceed ± 1 percent of the load, and the error of the indicated or recorded maximum jaw separation shall not exceed 1 mm. The central points of the two jaws of the machine shall be in the line of pull, the front edges shall be perpendicular to the line of pull, and their clamping faces shall be in the same plane. The jaws shall be capable of holding the specimen without allowing it to slip shall be so designed that they do not cut or otherwise weaken the specimen and shall be wider than the test specimen. The faces of the jaws should preferably be smooth and flat, but when the specimens cannot be held with flat-faced jaws satisfactorily even with packing, engraved or corrugated jaws may be used.

The machine shall be fitted with a suitable means of measuring increase in length of the central 100 mm section of the test specimen during the course of and at the completion of each test cycle.

NOTE — Pieces of felt approximately 3 mm thick have been found to be suitable for packing but the choice of type of jaws and packing should be that combination which gives the highest breaking load and does not cause an undue number of breaks in close proximity to the edges of the jaws. Suitable packing materials for use with either smooth or corrugated jaws include paper, felt, leather, plastics or rubber sheets.

2.1.1 *Constant-Rate-of-Traverse Machines*

After first 5 seconds of the test, average rate-of-traverse of pulling jaws in any 2 seconds interval shall not differ by more than 5 percent from average rate-of-traverse over the whole period of the test.

2.1.1.1 The rate of travel of the power-driven grip shall be 100 ± 10 mm/min. Alternative permitted rates of travel are 50 mm/min and 300 mm/min, when agreed between the manufacturer and the user.

3 TEST PIECE

3.1 Dimensions

The test piece shall be 50 ± 0.5 mm wide and of such a length as to permit separation of coating from the fabric over a length of at least 100 mm.

NOTE — Test piece shall be taken avoiding uncoated surface and selvedge and shall be taken from a distance of not less than 100 mm from the end of the roll.

3.2 Preparation

3.2.1 *Standard Method*

Where the strength of the coating film on the fabric exceeds the adhesive bond, as with thick films, prepare the test piece by carefully cutting the coating through to the fabric along two parallel cuts, *A* and *B* 25.0 ± 0.5 mm apart as shown in Fig. 1. Cut *A* extends from one end of the test piece to within 25 mm of the other end. Cut *B* extends to within 50 mm of that end. Join the ends of cuts *A* and *B* with a diagonal cut C, through the coating to the fabric. Work the edge of a knife under the point formed by cuts *A* and *C* and separate the peeling strip so formed from the fabric for a distance of 50 mm from that point.

3.2.2 *Alternative Methods*

3.2.2.1 *Using two pieces of the test material*

Take two pieces of the test material about 75 mm wide and about 200 mm long. Prepare the faces of the material by light buffing and cement the two pieces together using a suitable adhesive and applying it strictly in accordance with the recommendations of the adhesive suppliers.

The specimens shall be trimmed at each edge to give a width of 50 ± 0.5 mm. Make the cuts shown in Fig. 1 through one layer of fabric and both films to the other layer of treated fabric, and finish preparing the test piece as described in 3.2.1.

NOTES

1 In case, light buffing of the faces of material is likely to damage the surface of the material which may lead to affect the properties of the finished fabric, buffing should be avoided.

2 Following adhesives have been found suitable for particular applications:

a) *Adhesive system suitable for nitrocellulose coatings* – Coat the face of each test specimen, avoiding the first 50 mm, with a 5 percent solution of nitrocellulose in a mixture of two volumes of ethanol to one volume of acetone and heat the coated specimen at 70°C for 5 min.

b) *Adhesive system suitable for polyurethane coatings* – Use a solution consisting of 12 parts of 30 percent solution of a soluble polyester/isocyanate prepolymer, a part of a 75 percent solution of a polyisocyanate resin having an NCO content of approximate 13 percent in ethyl acetate and 1 part of a 10 percent solution of commercial accelerators in a mixture of ethyl cellulose and ethyl chloride.

NOTE — Where the test is to be conducted on material in process (namely freshly produced materials) as a means of quality control testing, the proportions of the above polyurethane adhesive should be modified to: 100 parts of prepolymer, 5 parts of resin and 5 parts of accelerators.

3.2.2.2 *Using a plain weave cotton fabric desized and bleached peeling strip* – Take the test piece and a piece of cloth of the same dimensions, prepare the face of the material under test and apply three successive coats of a suitable adhesive to both material and the cloth peeling strip.

NOTES

1 The testing materials should give better adhesion than the tested materials. The material specified in IS 1544 : 1973 'Cotton Calico' is suitable provided it is desized.

2 In case of PVC or other plastic coated materials, care should be taken so that coating itself is not dissolved by the solvent used in adhesive.

3.2.2.3 *Using a 'build-up coat'*

Successively, build up by several applications, a bonded coat of approximately 0.5 mm thickness to facilitate removal of the original thin coating. For 'rubber' materials, use the appropriate self-vulcanizing cement; for PVC material, use a suitable PVC gel coat. When the 'build-up coat' has been applied and sufficiently vulcanized or gelled, prepare the test piece as described in 3.2.1.

3.3 Number of Test Pieces

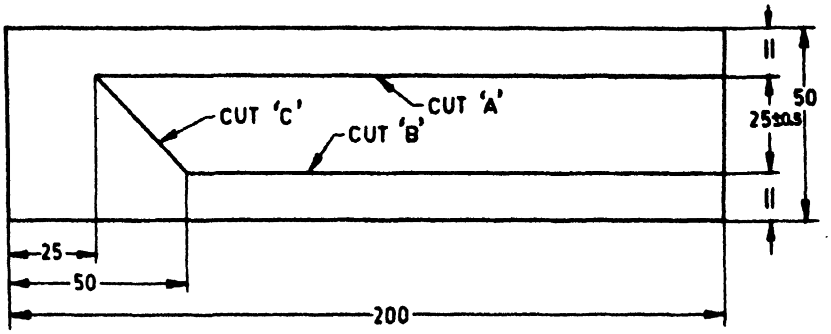
Prepare four test pieces, two in the warp direction and two in the weft direction.

3.4 Conditioning

a) For fabrics coated on one side, the minimum time between vulcanization or curing and testing shall be 16 hours.

b) For fabrics coated on both sides or where residual solvent is present, the minimum time between vulcanization or curing and testing shall be 7 days.

3.4.1 Expose the test piece freely at 27 ± 2°C and 65 ± 2 percent relative humidity for testing until they are in equilibrium. Equilibrium with the standard atmosphere for testing may be deemed to have been reached when successive determinations of mass, at interval of one hour, of the test specimens freely exposed to the moving air, differ by less than 0.1 percent. Subject to agreement between the purchaser and the supplier, the conditioning time may be curtailed to 48 hours or



All dimensions in millimetres.

FIG. 1 DIMENSIONS AND CUTTING LINES OF THE TEST PIECE

24 hours. Whenever possible, the time between vulcanization or curing and testing should not exceed three months. In other cases, tests shall be made within two months of date of receipt of the product by the customer.

4 PROCEDURE

4.1 Fix the separated ends of the test piece in grips of the testing machine and adjust it so that the tension is distributed uniformly and no twisting of the test piece occurs during the test.

4.2 Place the peeling strip in the power-driven grip and the backing strip in the non-driven grip so that the angle of separation is approximately 180°. It is important to ensure that the axis of the strips of the test piece held in the grips and the line of separation of the plies lie in the same plane, as shown in Fig. 2.

4.3 Set the force measuring system at zero. Continue the ply separation and record the force over a length of 100 mm.

5 EXPRESSION OF RESULTS

The adhesion strength of the test piece is calculated as the mean of the lowest 50 percent of the peak values taken from the central 50 percent of the stripping trace. The adhesion strength is expressed in newton per metre width. The adhesion strength shall be reported as the arithmetic mean of the results determined on duplicate test pieces.

6 TEST REPORT

The test report shall include the following particulars:

a) Reference to this method;

b) Details of the coated fabric from which the test pieces have been taken;

c) Number of test pieces, the direction of cutting with relation to the coated fabric, the adhesion strength values for each of the test pieces and actual method used for sampling preparation (*see* 3.2.1 and 3.2.2);

d) Arithmetic mean adhesion strength value in each direction;

e) Temperature of conditioning and test if other than as specified;

f) Rate of separation of the grip if other than 100 ± 10 mm/min;

g) Type of test piece, whether cemented or non-cemented; and

h) Details of any operation not specified in this standard and any other factors which may have influenced the results.

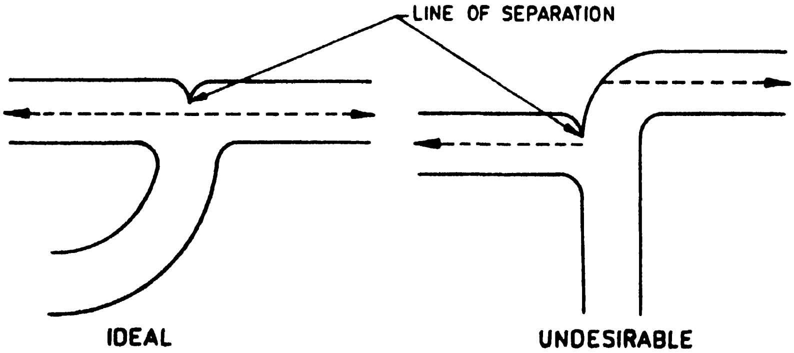


FIG. 2 POSITION OF LINE OF SEPARATIONS OF PLIES

METHODS OF TEST FOR COATED AND TREATED FABRICS

PART 6 DETERMINATION OF BURSTING STRENGTH

[*Source* : **IS 7016 (Part 6) : 1984**]

Two methods of test (A and B) have been included in this standard. Values obtained using Method A are not necessarily comparable with those obtained when using Method B. Therefore, when specifying a coated fabric for which a bursting strength requirement applies, the purchaser and the supplier should agree mutually the method of test to be employed.

Method A is recommended for use with those types of coated fabrics for which hydraulic bursting methods are not considered appropriate owing to the excessive pressures involved or where the risk of mechanical damage to the material in use is more relevant (for example, heavy weight double texture natural rubber coated fabrics).

This standard contains clauses **5.1** and **5.2** which call for an agreement between the purchaser and the supplier.

1 SCOPE

1.1 It prescribes two methods (A and B) for the determination of the bursting strength of coated and treated fabrics.

1.1.1 Method A uses tensile testing machine with a ring clamp and steel ball whilst Method B uses a diaphragm bursting tester operated by hydraulic pressure.

2 APPARATUS

2.1 Method A (*see* Fig.1).

2.1.1 *Principle*

A coated fabric is securely clamped between rigid coaxial apertures. A polished steel ball traversing at a fixed speed, is pressed against the coated fabric specimen until rupture occurs. The force required to cause the rupture is recorded.

2.1.2 *Tensile Testing Machine*

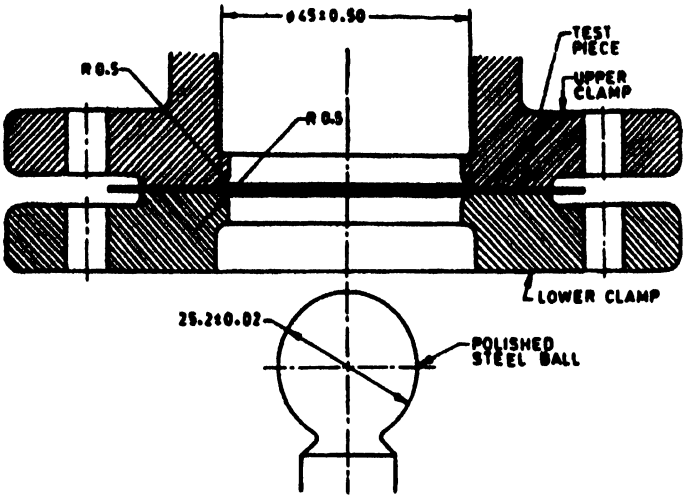
It shall be power driven and equipped with a suitable dynamometer. It shall be capable of maintaining a substantially constant rate of traverse of the moving head during the test and be fitted with an autographic recorder. An inertialess dynamometer (of electrical or optical type, for example) may be used. The accuracy of the machine shall be such that the error in the force measurement as shown and recorded does not exceed 2 percent of the force of 0.5 percent of the maximum of the scale, whichever is the greater.

NOTE — A pendulum-type inertia dynamometer may in fact give different results because of the effects of friction and inertia. When the use of an inertia dynamometer is unavoidable, information may be obtained in the following way. The capacity of the machine or the measuring scale selected, when a variable-range machine is involved, shall be such that the bursting force is between 15 percent and 85 percent of the rated capacity.

2.1.2.1 The tensile testing machine shall be provided with a bursting attachment, such that the test piece is held securely by a ring mechanism of internal diameter 45 ± 0.50 mm, with the centre of the test piece pressed against a polished steel ball of diameter 25.2 ± 0.02 mm until the test piece ruptures. The direction of motion of the ring-clamp or steel ball shall be at right angles to the plane of the fabric.

2.1.2.2 The central points of the two jaws of the machine shall be concentric and shall be in the line of pull, the front edges being perpendicular to the line of pull, and their clamping faces in the same plane. The jaws shall be capable of holding the specimen without allowing it to slip, shall be so designed that they do not cut or otherwise weaken the specimen, and shall be wider than the test specimen. The faces of the jaws should preferably be smooth and flat but when the specimens cannot be satisfactorily held with flat-faced jaws even with packing, engraved or corrugated jaws may be used.

In case of engraved jaws, the clamping surfaces of the upper and lower clamps shall be grooved concentrically such that the crowns of the grooves of one plate fit the



All dimensions in millimetres.

FIG. 1 APPARATUS FOR METHOD A

grooves of the other. The grooves shall be not less than 0.8 mm apart and not less than 0.15 mm deep. The grooves shall start no further than 3 mm from the edge of the aperture and shall be rounded to a radius of not greater than 0.4 mm. The lower inner edge of the upper clamp and the upper inner edge of the lower clamp shall be rounded off to a radius of 0.5 mm.

NOTE — Pieces of felt approximately 3 mm thick have been found to be suitable for packing, but the choice of type of jaws and packing should be that combination which gives the highest breaking load and does not cause an undue number of breaks in close proximity to the edges of the jaws. Suitable packing materials for use with either smooth or corrugated jaws include paper, felt, leather, plastics or rubber sheet.

2.2 Method B (*see* Fig. 2)

2.2.1 *Principle*

A coated fabric specimen is clamped between coaxial apertures. An elastic diaphragm is caused to exert pressure on the coated fabric specimen by the introduction of liquid below the diaphragm at a constant rate. The pressure required to cause the coated fabric specimen to burst is recorded.

2.2.2 *Testing Machine*

It shall be either mechanically or manually operated. It shall permit the clamping of the test piece between two circular clamps of diameter not less than 55 mm and having coaxial apertures of 30 ± 0.5 mm diameter.

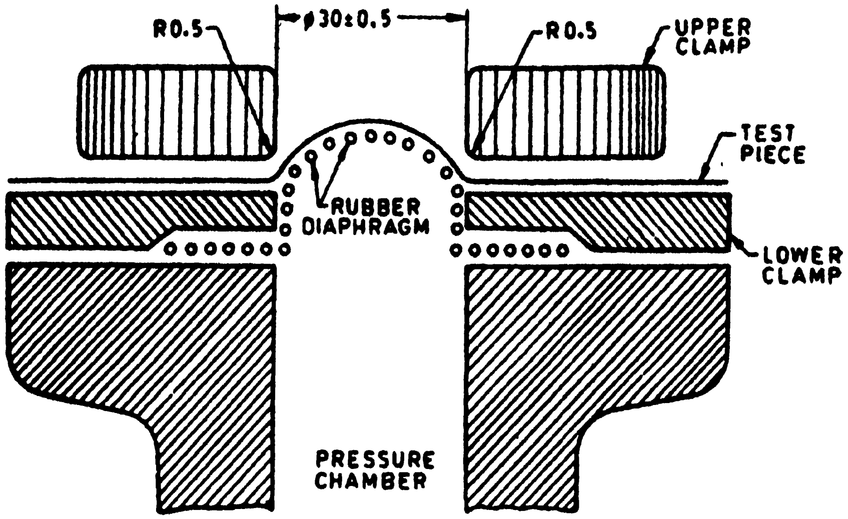
2.2.2.1 The clamping surfaces of the upper and lower clamps shall be grooved concentrically such that the crowns of the grooves of one plate fit the grooves of the other. The grooves shall be not less than 0.8 mm apart and not less than 0.15 mm deep. The grooves shall start no further than 3 mm from the edge of the aperature and shall be rounded to a radius of not greater than 0.4 mm. The bottom inner edge of the upper clamp shall be rounded to a radius of 0.5 mm. The lower clamp shall be integral with the chamber in which liquid is introduced. The chamber shall be covered with a rubber diaphragm fitted to expand through the aperture and exerting pressure on the coated fabric between clamps.

2.2.3 *Pressure Gauge*

The apparatus shall be provided with a means for transmitting hydraulic pressure to the rubber diaphragm. A pressure gauge of the maximum reading type, of appropriate capacity and graduated in kgf/cm^2 or kilopascals shall be provided for registering the bursting pressure. It shall preferably be used within the range from 25 percent to 75 percent and in no case outside the range from 15 percent to 85 percent of the maximum capacity of the scale. It shall at any point within the working range be accurate to within 1 percent of the maximum capacity of the scale. The pressure gauge shall be calibrated at least once in a year to maintain the specified accuracy.

3 SAMPLING

The sample shall be so cut that it is as representative as possible of the whole consignment. The test pieces shall be cut at least 100 mm from the selvedge and at least 1 m from the extremity of the piece.



All dimensions in millimetres.

FIG. 2 APPARATUS FOR METHOD B

4 PREPARATION OF TEST PIECES

Cut across the full width of the sample, a rectangular strip not less than 100 mm wide so that its sides make an angle of 45 ± 15° with the longitudinal direction. Take six test pieces, equally spaced across the width of the sample. The smaller dimension of each test piece shall be at least 12 mm greater than the outside diameter of the ring clamp mechanism of the test machine. Alternatively, the sample may be tested at the requisite location across its width.

5 CONDITIONING OF TEST PIECES

5.1 For all test purposes, the minimum time between manufacture and testing shall be 16 hours. For non-product tests, the maximum time between manufacture and testing shall be 4 weeks and for evaluations intended to be comparable, the tests, as far as possible should be carried out after the same time-interval. For products, whenever possible, the time between manufacture and testing should not exceed 4 months. In other cases, tests should be made within 2 months of the date of receipt by the customer.

5.2 Conditioning

Condition the test pieces at 27 ± 2°C and 65 ± 2 percent relative humidity for 48 hours prior to testing. Subject to agreement between the purchaser and the supplier, the conditioning time may be curtailed to 24 hours.

5.3 When it is required to determine the properties of wet material, the test pieces shall be immersed for 24 hours in distilled water containing 1 percent ethanol at 27 ± 2°C. The test pieces shall be cut prior to the immersion. Immediately after removal from the water, the test pieces shall be blotted between two sheets of absorbent paper and tested at once.

6 PROCEDURE

6.1 Method A

6.1.1 Mount the conditioned test piece in the ring clamp. Move the test piece and steel ball towards each other at a rate of 300 ± 30 mm/min until the test piece ruptures under the pressure being applied by the steel ball. Read from the scale of the tensile testing machine the force in newtons to cause the rupture of the test piece.

NOTE — For single coated fabrics place the coated face of the test piece downwards and for double coated fabrics test three pieces with the face side upwards, and three with the face side downwards.

6.1.2 Calculate the bursting strength, in kilo-pascals, using the relation:

$$\text{Bursting strength} = \frac{F \times 10^6}{A}$$

where

F = rupturing force, in kilonewtons; and
A = internal cross-sectional area, in square millimetres of the ring-clamp.

Record the mean of the six results obtained.

6.2 Method B

6.2.1 Place the conditioned test piece over the rubber diaphragm of the apparatus (*see* Note under **6.1.1**). Secure the clamping ring tightly over the test pieces and increase the pressure on the rubber diaphragm by introducing liquid into the chamber until the test piece bursts. Allow between 7 and 20 seconds for the pressure to increase from zero to bursting point. Record the pressure required as shown by the maximum indicating point on the gauge and return the pointer to zero. For each test piece, record the bursting pressure and note the form of bursting obtained (namely cross of slit).

NOTE — Ignore any burst which occurs at or near the edge of the clamp and repeat the test on another test piece.

6.2.1.1 Calculate the mean of the six results obtained for bursting pressure and then apply the diaphragm correction factor as given in **6.2.2**.

6.2.2 *Correction Factor*

With the same rate of liquid flow as that employed in the test (*see* **6.2.1**), distend the diaphragm, without the presence of the specimen, but with the clamping ring in position, and note the pressure required to distend it by an amount equal to the average distension of the specimen at burst. This pressure is the 'diaphragm correction factor' and is the value by which the mean bursting pressure should be reduced.

6.2.3 Report the corrected mean bursting pressure as the bursting strength.

7 TEST REPORT

The test report shall state:

a) Reference of the sample;
b) Conditioning method and the time of exposure;
c) Conditions in which the test has been conducted;
d) Method of test employed (A and B) and aperture used;
e) Bursting strength, expressed in kilo-pascals; and
f) For method B, the form of bursting obtained.

METHODS OF TEST FOR COATED AND TREATED FABRICS

PART 7 DETERMINATION OF RESISTANCE TO PENETRATION BY WATER

[*Source* : **IS 7016 (Part 7) : 1986**]

This method is an important performance criteria as it determines the ability of rubber or plastic coated fabric to withstand against water. In order to determine the degree of penetration by water, it is necessary to subject test pieces cut from the coated fabric to known hydrostatic pressure. These tests may be conducted on coated fabrics as produced or on test pieces which may have been subjected to ageing or other tests.

This test method is applicable to all types of treated/coated fabrics whether treated/coated on one or both sides.

1 SCOPE

1.1 It prescribes methods for determining the resistance to penetration by water of fabrics coated with rubber or plastics when subjected to a low or high hydrostatic pressure.

1.1.1 Four methods are covered, as follows:

Method A1 or A2:	Hydrostatic pressure method – Low range
Method B1 or B2:	Hydrostatic pressure method – High range

1.2 The choice of methods is optional, but consideration should be given to the nature of service for which correlation test values may be sought.

2 CONDITIONING

Condition the test pieces at 27 ± 2°C and 65 ± 2 percent relative humidity for 48 hours prior to testing. Subject to agreement between the purchaser and the supplier, the conditioning time may be curtailed to 24 hours. For all test purposes, the minimum time between vulcanization or curing and testing shall be 16 hours. Whenever possible the time between vulcanization or curing and testing should not exceed three months. In other cases, tests shall be made within two months of the date of receipt by the customer of the product.

3 METHOD A – HYDROSTATIC PRESSURE METHOD – LOW RANGE

3.1 Apparatus

The apparatus shall consist of a central well fitted with a coaxial ring clamp to fasten the test piece over the well. The apparatus shall introduce water at test-room temperature from above or below the test piece over a circular area 100 cm^2 (approximately 113 mm diameter) in diameter at the rate of 10 ± 2 mm of hydrostatic head per second. The rubber tubing connecting the constant-level device and the well shall have an inside diameter of not less than 6 mm.

3.2 Test Piece

3.2.1 The test piece shall be either circular, of diameter 130 to 200 mm, or of corresponding square shape. It shall be taken at least 0.10 m from the selvedge and 1 m from the end of the roll.

3.2.2 Unless otherwise specified in the material specification, five test pieces shall be tested from each sample unit.

3.3 Procedure

Conduct the test according to one of the following methods.

3.3.1 *Method* A1

Wipe all surface water from the clamping surfaces. Lay the test piece smoothly on the face of the lower ring of the clamp and fasten the upper plate in place, ensuring that the coated fabric is in contact with the water and that no air is trapped between the test piece and the water. This shall form a watertight compartment. If the test piece is coated on only one side, place the coated side next to the water, unless otherwise specified. In the case of double coated fabrics, place the more heavily coated side next to the water, unless otherwise specified. With the leveller at the zero position, turn the water on and keep in running at such a rate as to overflow continuously. Raise the constant level device at a rate of 10 mm/s until the first drop of water appears on the underside of the test piece. No account shall be taken of very fine droplets of water which are formed at or near the clamping edge. Read on the scale the height of the water above the lever of the test piece.

3.3.2 *Method* A2

Place the test piece in the clamp, raise the water column to a predetermined height (1 or 10 m) and record the time at which the first drop of water appears on the underside of the test piece.

3.4 Test Report

The test report shall include the following particulars:

a) The method and procedure used;

b) The number of test pieces tested;

c) With method A1, the height of the water column, in millimetres, at which the first drop of water appeared on the underside of the test piece, and the average value for all test pieces;

d) With Method A2, the predetermined height of the water column and the elapsed time before the first drop of water appeared on the underside of each test piece, and the average value for all test pieces;

e) Identification of the material tested;

f) If applicable, the conditions used for ageing the test pieces; and

g) To which side of the coated fabric the water pressure was applied.

4 METHOD B – HYDROSTATIC PRESSURE METHOD – HIGH RANGE

4.1 Apparatus

4.1.1 The apparatus shall consist of a hydrostatic tester capable of supplying a minimum pressure of 690 kPa[1] with an accuracy of ± 7.0 kPa.

4.1.2 The apparatus shall be equipped with two concentric ring clamps, having an inner diameter of 31.5 ± 0.5mm, between which the test piece can be clamped. The clamping surfaces shall have concentric grooves of depth not less than 0.15 mm to prevent the test piece from slipping during the test. The inside edges of the ring clamps that come into contact with the test piece shall be rounded to a radius of 0.3 to 0.5 mm to avoid cutting of the test piece.

4.1.3 The lower clamp shall be fitted with a rubber O-ring to avoid leakage when the pressure is applied to the test piece.

4.1.4 The machine shall have means for applying hydraulic pressure to the underside of the clamped test piece until the test piece fails.

4.1.5 The pressure gauge shall be of the Bourdon maximum-reading type, with graduations which will permit reading for the entire scale within 1.0 percent of its maximum capacity. The capacity of the gauge shall be such that the individual readings will be not less than 25 percent and not more than 75 percent of the total capacity of the gauge.

4.2 Test Pieces

4.2.1 At least five test pieces shall be cut from samples taken at random from the roll of coated fabric being tested. The smallest dimension of the test piece shall be at least 12 mm greater than the outside diameter of the ring clamp mechanism of the testing apparatus.

4.2.2 The test pieces shall be taken at least 0.10 m from the selvedge and 1 m from the end of the roll.

4.3 Procedure

Conduct the test according to one of the following methods.

4.3.1 *Method* B1

Before clamping the test piece into the testing machine, bring the water level up flush with the top of the O-ring so that no air pocket exists between the water surface and test piece. Unless otherwise specified in the case of single coated fabrics, place the coated side next to the water. In the case of double-coated fabrics or double-textured fabrics, place the more heavily coated side next to the water, unless otherwise specified. The temperature of the water shall be the same as the atmospheric temperature of the testing room, unless otherwise specified. Increase the pressure at uniform rate of displacement and take a dial reading at the first appearance of water through the test piece.

4.3.2 *Method* B2

The specimen should be flexed five times by applying and releasing the specified pressure. Apply the specified pressure held constant within ± 7.0 kPa, against the test piece for a period of 5 minutes. Any appearance of water through the test piece that can be detected during the specified period will indicate failure to pass the test.

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[1] 1 kPa = 0.010 2 kgf/cm².

4.4 Test Report

The test report shall include the following particulars:

a) The method and procedure used;

b) The number of test pieces tested;

c) With Method B1, all observed and recorded date together with the average value of hydrostatic resistance, in kPa;

d) With Method B2, the specified pressure applied and the number of test pieces that withstood pressure;

e) Identification of the material tested; and

f) If applicable, the specific conditions used for ageing or other testing.

METHODS OF TEST FOR COATED AND TREATED FABRICS

PART 8 ACCELERATED AGEING

[*Source* : IS 7016 (Part 8) : 1975]

It is not possible to follow the same procedure for accelerated ageing test for fabrics coated with rubber and plastics as adopted for other rubber and plastics goods, the main reasons being relatively large area coupled with thin coatings which will not normally provide test pieces suitable for measurement of physical properties.

It is not feasible to establish a fixed and universal relationship between the duration of ageing in the oven and the useful life of the objects; such relationships can be established only for each individual case.

1 SCOPE

It prescribes the methods of test for accelerated ageing and simulated service tests of coated and treated fabrics.

2 TEST METHODS

2.1 The following two ageing tests are given:

a) Oven method, and
b) Oxygen pressure method.

2.2 For all test purposes, the minimum time between vulcanization or curing and testing shall be 16 hours. Whenever possible, the time between vulcanization or curing and testing shall not exceed three months. In other cases, tests shall be made within two months of the date of receipt of the product by the customer.

3 TEST PIECES

Test pieces shall be taken at not less than 100 mm from the selvedge and not less than 1 m from the end of the roll or piece. The size of the test piece depends upon the property to be examined. For examination of properties, such as tear, waterproofness, etc, the dimensions of the test piece shall be those required by the particular method. For purposes of ascertaining the degree of stiffness, or decomposition, a test piece not less than 100 mm × 50 mm for the oven method and not less than 75 mm × 25 mm for the oxygen pressure method shall be used.

4 OVEN METHOD

4.1 Apparatus

The air-oven shall be of such a size that the total volume of the test pieces does not exceed 10 percent of the free air space of the oven. Provision shall be made for suspending test pieces vertically so that they are not within 10 mm of each other or the sides of the oven. Provision shall be made for slow circulation of air in the oven of not less than three changes and not more than ten changes per hour. Care shall also be taken that the incoming air is heated to the temperature of the oven before coming into contact with the test pieces. The temperature of the oven shall be thermostatically controlled so that the test pieces are kept within ± 1°C of the specified ageing temperature. A thermometer shall be placed near the centre of the test pieces being aged to record the actual ageing temperature.

NOTE — Copper or copper alloys or both together shall not be used for the construction of oven

4.2 Procedure

Place the test pieces in the oven vertically after they have been preheated to the operating temperature. The test pieces are to be stationary, free from strain, freely exposed to air on all sides and not exposed to light. When the ageing period is complete, remove the test piece from the oven and store and condition at room temperature for not less than 16 h or more than 96 h, in a strain-free condition and then condition in accordance with the details given in the appropriate test method for the particular physical property being studied.

4.2.1 Where ageing is conducted on the 100 mm × 50 mm test pieces, they shall be observed and handled for any signs of softening, stiffening, tackiness, brittleness, discolouration, or other loss of properties, and the presence or absence of the characteristic odour of decomposition shall be noted. This shall be done in comparison with the unaged material.

Where the test pieces are exposed at a temperature of 100°C they shall also be examined for additional properties, such as tensile strength and tear. The duration of test shall be 1, 3, 7, 10 or some multiple of 7 days and the temperatures of test shall be 70 ± 1°C or 100 ± 1°C as may be stipulated in the individual material specification. The pressure shall be atmospheric.

4.2.2 As far as possible, avoid simultaneous ageing of different types of compounds in order that migration of sulphur, anti-oxidants, plasticizers or stabilizers may not occur. As a guideline, samples may be aged together where the following conditions are satisfied :

a) Polymers are of the same general type;
b) Vulcanizates having the same sulphur content;
c) Vulcanizates having broadly the same type of anti-oxidants, anti-ozonants and UV absorbers; and
d) Vulcanizates having plasticizers of approximately the same volatility.

5 OXYGEN PRESSURE METHOD

5.1 Apparatus

The oxygen pressure chamber shall consist of a vessel of stainless steel or other suitable material designed to retain an internal atmosphere of oxygen under pressure with provision for placing test pieces within it and subjecting them to controlled uniform temperature. The size of the vessel is optional but shall be such that the total volume of the test pieces does not exceed 10 percent of the free space of the vessel. Copper or brass parts shall be neither within the ageing chamber not used in the construction of the tubing leading through the oxygen reservoir to the ageing chamber. The heating medium which surrounds the vessel is thermostatically controlled and a thermometer shall be immersed in the heating medium. The pressure chamber shall be equipped with a reliable safety valve set at 3 400 kN/m^2 (approx 34 kgf/cm^2) and a pressure gauge shall be connected to the apparatus.

NOTE — The heating medium is optional. Water, air or other fluids known to be safe in the presence of oxygen may be used. Water has an advantage because of its rapid heat transfer and non-combustible nature. If air is used, the heated air shall be thoroughly circulated by means of mechanical agitation and baffles shall be used as required to prevent local overheating and dead spots. Oils or other combustible fluids are extremely hazardous in the presence of oxygen and should not be used as a heating medium for this test.

5.2 Procedure

Heat the test pieces to the operating temperature suspended vertically in the pressure chamber after it has been dried. Before commencing the test, flush out the air inside the chamber by allowing oxygen into it and keeping the outlet valve open for sufficient time. The chamber is then filled with oxygen to the required pressure. Maintain the test pieces in the vessel stationary, free from strain and freshly exposed to the oxygen on all sides. Pass oxygen into the pressure chamber at a pressure of 2 050 ± 100 kN/m^2 (approx 20.5 ± 1 kgf/cm^2) maintaining the exposure continuous for the specified time, without pressure reduction or opening of the chamber. The temperature shall be maintained at 70 ± 1°C. The duration of the test shall be 24 hours or some multiple thereof.

5.2.1 When the ageing period is complete, release the pressure in the pressure chamber slowly and uniformly (this requires at least five minutes), taking particular care to see than all the pressure is released as indicated by the pressure gauge. Remove the test pieces from the vessel and condition in accordance with the details given in the appropriate test method for the particular property being studied.

5.2.2 As far as possible, avoid simultaneous ageing of different types of compounds in order that migration of sulphur, anti-oxidants, plasticizers of stabilizers may not occur. As a guideline, samples may be aged together where the following conditions are satisfied :

a) Polymers are of the same general type;
b) Vulcanizates having the same sulphur content;
c) Vulcanizates having broadly the same type of anti-oxidants, anti-ozonants and UV absorbers; and
d) Vulcanizates having plasticizers or approximately the same volatility.

6 EXPRESSION OF RESULTS

6.1 State the number of test pieces and express the results in accordance with the recommendations of the appropriate test method for the particular test being carried out.

6.2 Determine the properties of the test pieces aged for different periods as the intervals terminate in the process of ageing.

6.3 Report the test results of both the unaged (O) and the aged (A) test pieces and record percentage change in physical or mechanical property using the formula :

$$\frac{O-A}{O}\times 100$$

where

O = mechanical or physical properties of the test piece expressed in appropriate units before ageing, and
A = mechanical or physical properties of the test piece expressed in the same units after ageing.

6.4 State the physical or mechanical properties determined and ageing conditions.

METHODS OF TEST FOR COATED AND TREATED FABRICS

PART 9 DETERMINATION OF BLOCKING RESISTANCE

[*Source* : **IS 7016 (Part 9) : 1988**]

Blocking tests at elevated temperatures are designed to estimate the relative resistance of fabrics coated with rubber or plastics to blocking. For this purpose, the coated fabric is subjected to a specified load over a defined area at a specific temperature. The selection of the conditioning time and temperature depends on the type of coating to be evaluated. This selection determines whether an accelerated temperature or simulated service (heat) test is to be used.

1 SCOPE

It prescribes a method for determining the resistance of fabrics coated with rubber or plastics to blocking.

2 TERMINOLOGY

Blocking – Unintentional adhesion between plastic films or sheetings, or between film or sheeting and another surface.

3 APPARATUS

3.1 **Glass Plates** – approximately 112 mm × 112 mm × 3 mm.

3.2 **Weight-Pieces** – of mass 5.0 kg.

3.3 **Oven** – Circulating air oven of such a size that the total volume of the test assemblies does not exceed 10 percent of the free air space of the oven. Provision shall be made for placing the test assemblies on shelves so that they are not less than 50 mm from each other or from the sides of the oven. The nature of the source of heat is optional but the source shall be located in the air supply of the oven. Provision shall be made for circulation of air through the oven at a rate such as to provide a minimum of six air changes per hour. The temperature of the oven shall be thermostatically controlled to maintain the temperature of the test assemblies within ± 2°C of the specified temperature. Baffles shall be used as required to prevent overheating and dead-spots.

4 TIME INTERVAL BETWEEN MANUFACTURE AND TESTING

4.1 For all purposes, the minimum time between manufacture and testing shall be 16 h.

4.2 For product tests, whenever possible, the time between manufacture and testing should not exceed four months. In other cases, tests should be made within two months of the date of receipt by the customer.

5 TEST PIECES

5.1 The test pieces for each sample to be tested shall consist of six specimens, each 150 mm × 150 mm.

5.2 Test specimens shall be representative of the material being tested. They shall be taken at least 0.10 m from the edges of the coated sample and well away from the end. They shall be cut with one edge parallel to the longitudinal axis of the sample. The longitudinal and lateral axis shall be marked on the test specimens.

6 CONDITIONING OF TEST PIECES

Cut test pieces shall be conditioned, immediately before testing, for a minimum or 48 h at 27 ± 2°C and 65 ± 2 percent relative humidity.

7 PROCEDURE

7.1 Arrange the test specimens in pairs, back to back, face to face and back to face, to form a pile 100 mm square. Place the test specimens thus arranged between two glass plates (**3.1**). Place the 5.0 kg weight-piece (**3.2**) on the top plate in the position to ensure an even distribution of pressure.

7.2 Expose the test assembly for 3 h at a temperature of 70 ± 2°C in the oven (**3.3**).

7.3 At the end of the exposure period, remove the test assembly from the oven, immediately take the test piece from between the plates and allow it to cool for 3 h. Then carefully separate the test specimens and examine them for adherence or peeling of the coatings.

7.4 Rate the resistance of the test piece to blocking by the scale given below :

a) *No blocking* – coated surfaces separate without any evidence of adhering,

b) *Slight blocking* – some adherence of coated surfaces takes place on separation but without detriment to the coating, and

c) *Blocking* – coated surfaces are difficult to separate and the coating or a part of the coating is removed during separation.

8 TEST REPORT

The test report shall include the following particulars:

a) Reference to this test method;

b) Identification of the sample;

c) Total mass on the test piece;

d) Rating for resistance to blocking, in accordance with **7.4**; and

e) Any departure from the procedure specified.

METHODS OF TEST FOR COATED AND TREATED FABRICS

PART 10 LOW - TEMPERATURE BEND TEST

[*Source* : **IS 7016 (Part 10) : 1981**]

Bend test at low temperature is designed for determining the ability to resist cracking or fracturing of coating of fabrics coated with rubber or plastics when exposed for definite periods at specified temperature.

1 SCOPE

1.1 It prescribes a method for determining the ability of fabrics coated with rubber or plastics to resist the effect of low temperature when subjected to bending at specified temperatures after definite periods of exposure. It is applicable to material with a thickness within the range 0.10 to 2.20 mm.

1.1.1 Fabrics coated with rubber or plastics are used in many applications requiring low temperature flexing. However, no relation between this test and service performance can be given or implied.

2 APPARATUS

2.1 Cold Chamber

A chamber sufficient in size to contain the bending fixture used for testing the test pieces and to permit the operation of the fixture to bend the test piece without removal from the chamber. The cold chamber shall also have sufficient work space to permit the conditioning of test pieces as outlined in **5**. It shall be capable of maintaining a uniform atmosphere of cold air or any other suitable gas at specified temperatures within at tolerance of ± 1°C.

2.2 Bending Jig

For bending the test pieces, as shown in Fig. 1 and 2.

2.3 Glass Plates

Sufficient number of glass plates having dimensions of approximately 125 mm x 175 mm. The thickness of the glass plates shall be such as to permit easy handling.

2.4 Gloves

For handling test pieces within the cabinet and which shall be exposed to the same temperature as the test pieces.

3 TIME LAPSE BETWEEN MANUFACTURE AND TESTING

3.1 For all test purposes the minimum time between manufacture and testing shall be 16 hours, in order to ensure that the material attains dimensional stability due to stress relaxation.

3.2 In order to bind the user and supplier to a stipulated time for carrying out conformity test for supplied material, the following shall apply.

3.2.1 For non-product test, separate test piece is required for testing. Therefore, the maximum time between manufacture and testing shall be 8 weeks and for evaluation intended to be comparable, the tests as far as possible, should be carried out after the same time interval.

3.2.2 For product test whenever possible the time between manufacture and testing should not exceed 6 months. In other cases tests shall be made within 4 months of the date of the receipt of the product by the customer.

4 TEST PIECES

4.1 Dimensions

The test pieces shall be 25 mm wide by 100 mm long. They shall be cut with the longer dimension parallel to the length wise direction of the sample, unless otherwise specified.

4.2 Number

At least three test pieces shall be cut from each sample being tested.

5 CONDITIONING OF TEST PIECES

Cut test pieces shall be conditioned, immediately before testing, for a minimum of 48 hours at 27 ± 2°C and 65 ± 2 percent relative humidity.

6 PROCEDURE

6.1 Place the three test pieces between glass plates (2.3) with sufficient space between each test piece to permit the passage of air during the conditioning period. Place the glass plates with the test pieces held in position, the bending jig (2.2) and the gloves (2.4) in the cold chamber (2.1). Unless otherwise specified, expose them for 4 hours to the specified test temperature.

6.2 At the termination of the exposure period and while still in the test chamber, remove the test pieces from between the glass plates one at a time (*see* Note) and place in the bending jig with the flexing plate held in the open position by the trigger pin. Unless otherwise specified, in the case of substrates coated on one side only, place the coated side away from the mandrel. In the case of double-coated fabrics either surface may be evaluated unless otherwise specified.

NOTE — Gloves must be worn at all times when handling test pieces prior to making the bend test.

6.3 As soon as the test piece is in position in the bending jig, release the trigger and permit the flexing plate to make a free fall.

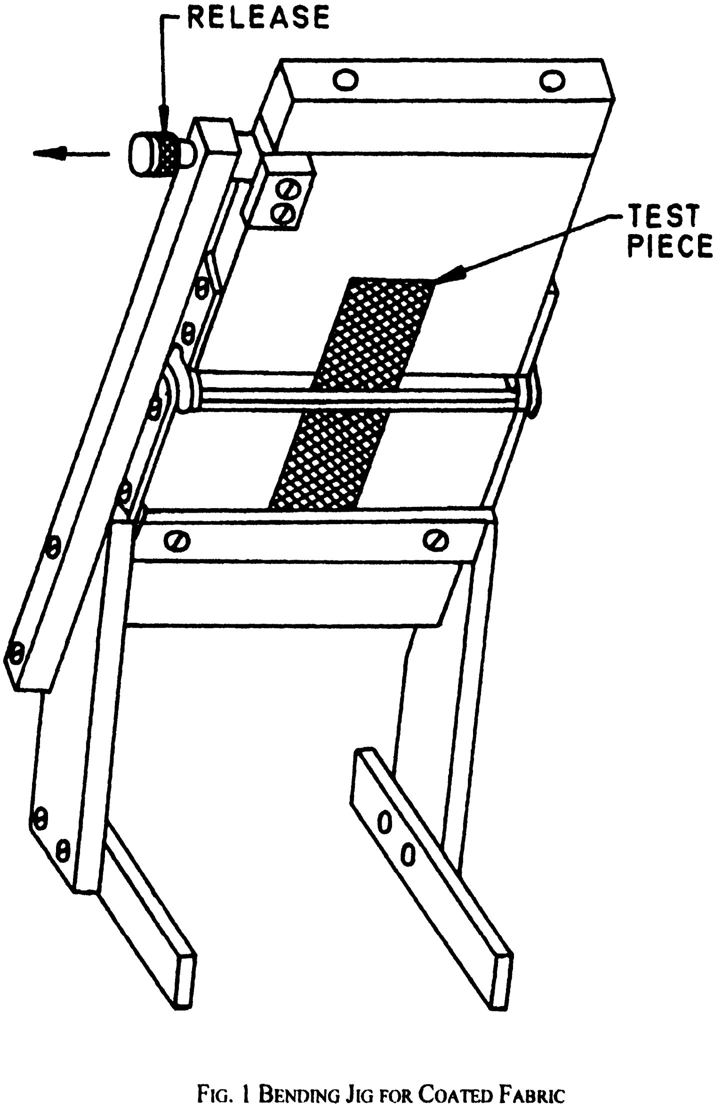


Fig. 1 Bending Jig for Coated Fabric

6.4 After all test pieces have been tested, remove them and examine for fractures or cracks in their coating under a magnification of 10 X . During the examination, fold all test pieces 180° in the same direction as the bend during the test.

7 INTERPRETATION OF RESULTS

If for all three test pieces the coating remains continuous, that is, free from any fractures or coating crack, the material shall be considered to have passed the test. If all the three test pieces fracture or show cracks, the material shall be considered to have failed. If only one or two test pieces show failure, test three additional test pieces. If any of these show fractures or coating cracks, the material shall be considered to have failed. If none of the samples show any crack it shall be considered to have passed the test.

8 TEST REPORT

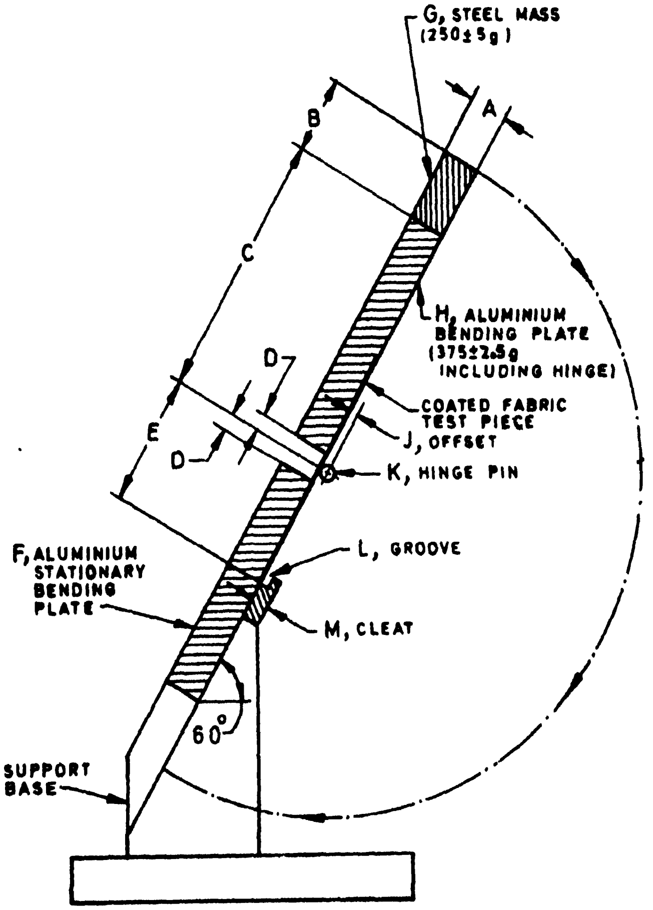
The test report shall include the following particulars:

a) Results of the tests expressed as 'passed' or 'failed';

b) The thickness of the test pieces ;

c) The temperature at which the test pieces were tested; and

d) The duration of the exposure period.



All dimensions in millimetres.

FIG. 2 BENDING JIG, SCHEMATIC DIMENSIONS

METHODS OF TEST FOR COATED AND TREATED FABRICS

PART 11 DETERMINATION OF FLEXIBILITY-FLAT LOOP METHOD

[*Source* : **IS 7016 (Part 11) : 1987**]

Flat loop method provides useful information about the flexibility of treated fabrics. The height of the loop is an inverse measure of the flexibility.

Flat loop method is applicable to treated fabrics which are not too rigid to form a loop. The method may be carried out on the coated fabrics as delivered or which have undergone certain specified treatments.

1 SCOPE

1.1 It specifies a method of characterizing the flexibility of some rubber or plastics coated fabrics.

1.2 The method is not applicable to coated fabrics which are prone to rolling up or spiralling when they are cut into pieces of small dimension, nor is it applicable when the coated fabric is too rigid to make a loop.

2 PRINCIPLE

A loop is formed from a rectangular strip of coated fabrics, placed on a horizontal plane, by superposing the two ends which are then held together under a steel bar. The height of the loop is measured. The flexibility is characterized by the height of the loop; this is an inverse measure and the lower the loop height the greater is the flexibility.

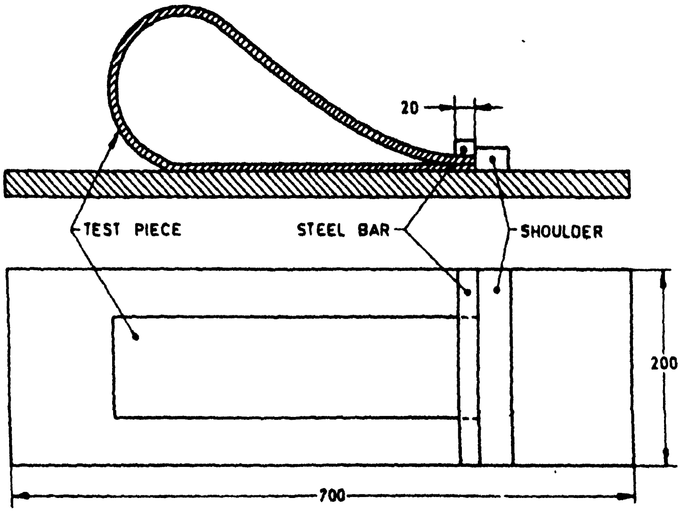
3 APPARATUS

3.1 Flat Rectangular Board

The board is equipped near one of its ends with a shoulder having its face perpendicular to the board.

NOTE — The dimensions shown in the Fig. 1 are given as an example; they may be increased to permit the installation of several test pieces on the same board.

3.2 Steel Bar — of stainless or non-corrosive steel, having a length of 200 mm and a square section of 20 mm side.



All dimensions in millimetres.

FIG. 1 APPARATUS FOR FLEXIBILITY DETERMINATION

3.3 Rule – Graduated in millimetres.

4 TEST PIECES

4.1 Shape and Dimensions

The test piece shall have the shape of a rectangle, 600 mm long and 100 mm wide.

4.2 Number

Use three test pieces cut in the longitudinal direction and three test pieces cut in the transverse direction.

4.3 Sampling

The test pieces shall be taken so that their outside edges are at a minimum distance of 100 mm from the edges of the coated part. They shall not be taken at a distance less than 1 000 mm from the ends of the coated part or at a location having a fold or an apparent defect.

5 TIME INTERVAL BETWEEN MANUFACTURING AND TESTING

5.1 For all purposes, the minimum time between manufacturing and testing shall be 16 h.

5.2 For non-product tests, the maximum time between manufacturing and testing shall be 4 weeks and for evaluations intended to be comparable, the tests, as far as possible, should be carried out after the same time interval.

5.3 For product tests, whenever possible, the time between manufacturing and testing should not exceed 3 months. In other cases, tests shall be made within 2 months of the date of receipt by the customer.

6 CONDITIONING OF TEST PIECES

The test pieces shall be conditioned at 27 ± 2°C and 65 ± 2 percent relative humidity for at least 24 h prior to testing. To avoid any deformation of the test pieces, they shall be placed, during conditioning, on a horizontal surface, the face that is to form the outside of the loop being turned upward.

NOTE — Different results may be obtained for different conditioning atmosphere.

7 PROCEDURE

7.1 Powder the surface of the board evenly with zinc stearate or French chalk. Holding the ends of the test piece between the fingers, place it on the board so that one side rests on the board and one end is against the shoulder (the choice of the side depends on the use of the product; it may be subject to agreement between the purchaser and the supplier; the test may also be repeated after having reversed the test piece side for side).

7.2 Bring the other end onto the first end (so as to form a loop), pressing it also against the shoulder. Place the steel bar on the superimposed ends. Keep the test piece in this position for 5 minutes.

7.3 Measure, with the rule, the maximum heights of the two edges of the loop for each of the test pieces with respect to the board.

8 EXPRESSION OF RESULTS

8.1 For each of the two directions there are three test pieces.

8.2 For each test piece cut in the longitudinal direction, express in millimetres the maximum height of each of the two edges of the loop formed. Take the arithmetic mean of the six values obtained as the result for the longitudinal direction.

8.3 Repeat the procedure described in **8.2** for test pieces cut in the transverse direction.

9 TEST REPORT

The test report shall include the following information:

a) indication of reference to the side(s) on which the results have been obtained;

b) each individual value obtained;

c) the arithmetic mean of the results for each test piece;

    i) for test pieces cut in the longitudinal direction;

    ii) for the test pieces cut in the transverse direction;

d) the condition of the test piece subjected to testing, and

e) whether the test was conducted on coated fabric as delivered or after it had undergone specified treatments (give details).

METHODS OF TEST FOR COATED AND TREATED FABRICS

PART 12 DETERMINATION OF TACK-TEAR RESISTANCE

[Source : **IS 7016 (Part 12) : 1987**]

Tack-tearing resistance provides useful information about the quality of coated fabrics, primarily vinyl plastic coated fabrics, used for furniture or automotive applications.

1 SCOPE

It prescribes the method for measurement of resistance of a coated fabric to tearing under conditions simulating an installation that has been tacked in place.

2 APPARATUS

The apparatus shall consist of the device illustrated in Fig. 1.

3 TESTING MACHINE

3.1 The machine shall consist of three main parts :

a) Straining mechanism,
b) Clamps for holding specimen, and
c) Load and elongation recording mechanism(s).

3.1.1 *Straining Mechanism*

A machine, wherein the specimen is held between the two clamps and strained by a uniform movement of the pulling clamp, shall be used. Unless otherwise specified in the material specification, the machine shall adjusted so that the pulling clamps shall have a uniform speed of 5 ± 0.2 mm/s.

3.1.2 *Load and Elongation Recording Mechanism(s)*

It shall consist of calibrated dial, scale or chart to indicate the applied load and elongation. Unless otherwise specified for load determination, the machine shall be adjusted or set so that the maximum load required to break the specimen will remain indicated on the calibrated dial or scale after the test specimen has ruptured.

3.2 Capacity

If the machine is of the pendulum type, it shall be of such a capacity that the maximum load required to break the specimen shall be not greater than 85 percent or less than 15 percent of the rated capacity.

3.3 Machine Efficiency – The error of the machine shall not exceed 2 percent up to and including a 200 N force (50-1bf) and 1 percent over 200 N and 1 percent at any reading within its loading range.

4 TEST SPECIMENS

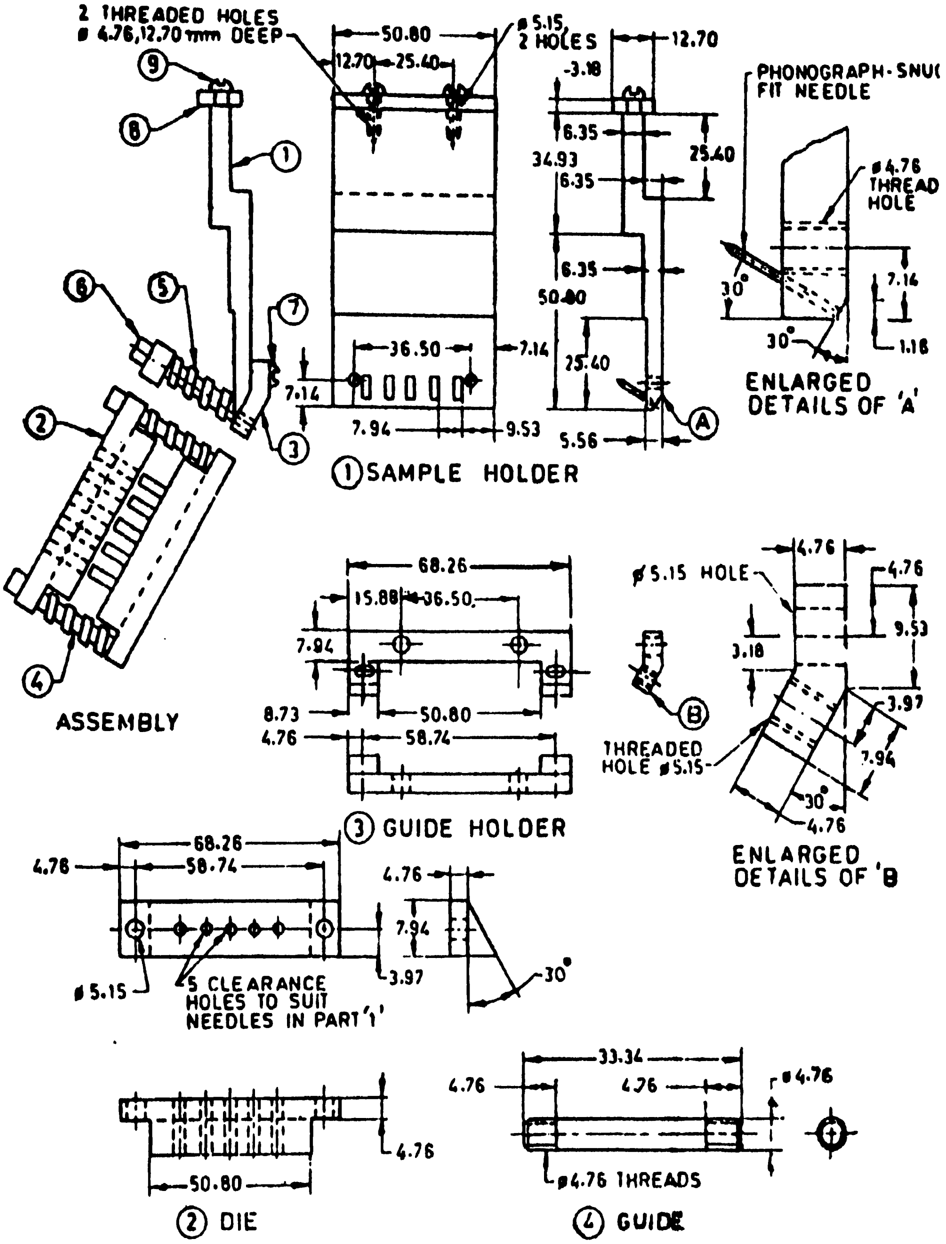
The specimens shall be 50 mm in width and 150 mm in length. Two sets of five specimens each are required, one set for warp tack-tear strength, having the longer dimension parallel to the filling yarns, and the other set for filling tack-tear strength having the longer dimension parallel to the warp yarn.

5 PROCEDURE

Clamp the device shown in Fig. 1 in the upper jaw of the testing machine and adjust the machine to compensate for its weight. Impinge the specimen on the needles, taking care that the line of needles is parallel to the threads to be tested and exactly 12.5 mm from the top edge of the specimen. Clamp the specimen in the lower clamp. Operate the machine as for a tension test with the distance from the bottom of the needles to the top of the lower clamp as 75 mm and the rate of jaw separation as 5 mm/s with no load. The faces of the bottom clamp shall measure 25 by 75 mm or more. If the machine is of the pendulum type, disengage the pawls on the pendulum from the ratchet. Record the average force necessary to tear the fabric, preferably with an autographic recording device.

6 EXPRESSION OF RESULTS

Report the median of results of five individual tests on the warp as the warp tack-tear strength, and the median of five individual tests on filling as the filling tack-tear strength.



All dimensions in millimetres.

Part No.	*Req*	*Metal*	*Description*
1	1	Hrs	Sample holder
2	1	Hrs	Die
3	1	Hrs	Guide holder
4	2	Hrs	Guide
5	2	Stl	Spring 5.6 mm ID-0020 dia-7 Coils-25 mm
6	2	Stl	4.76-24 nuts
7	2	Stl	4.76-24-9.53 mm long mach screws
8	1	Hrs	Cap
9	2	Stl	4.76 mm -24-12.7 mm long mach screws

FIG. 1 TACK-TEAR TESTER FOR COATED FABRICS

METHODS OF TEST FOR COATED AND TREATED FABRICS

PART 13 DETERMINATION OF CRUSH RESISTANCE

[*Source* : **IS 7016 (Part 13) : 1987**]

1 SCOPE

1.1 It prescribes a method for determining the crush resistance of fabrics coated with rubber or plastics.

1.2 The method is applicable particularly to diaphragm material cut from coated fabrics.

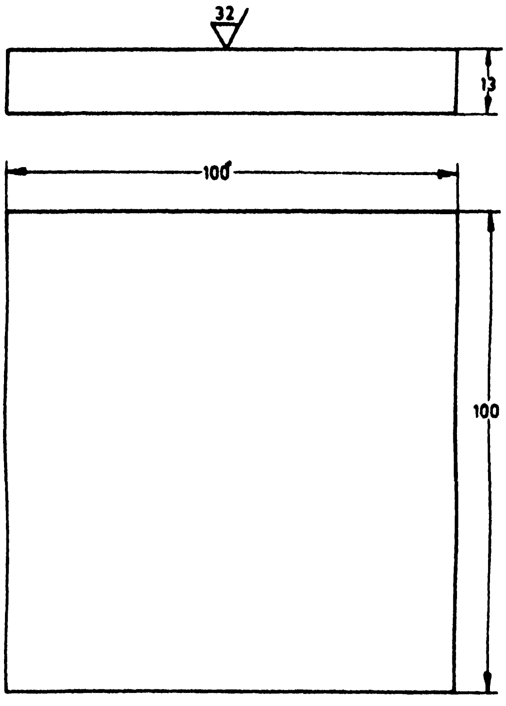
2 OUTLINE OF THE METHOD

The coated fabric is subjected to a controlled load application over a known area until the fabric is crushed.

3 APPARATUS

3.1 Bast Plate -- Having the dimensions shown in Fig. 1

3.2 Load Button Assembly – Having the dimensions shown in Fig. 2.



All dimensions in millimetres

FIG. 1 BASE PLATE

3.3 Compression Testing Machine

Having a speed of approximately 0.08 mm/s.

3.3.1 Any other type of machine that will meet this requirement may also be used. For example, a platform scale equipped with a yoke over the platform and a hand-operated screw to apply the force will serve if it conforms to the requirements prescribed for accuracy and speed.

3.3.2 The load source shall have a total capacity of at least 5 400 N.

3.4 Force-Recording Mechanism

A calibrated dial with a maximum pointer, or a strip-chart to indicate force required to crush the fabric. Unless otherwise specified for force determination, the machine shall be so adjusted that the maximum force required to crush the test piece may be readily detected by the maximum pointer or read from the strip-chart. The error of the machine shall not exceed 2 percent up to and including 200 N force and 1 percent over 200 N force at any reading within the loading range.

4 TEST PIECES

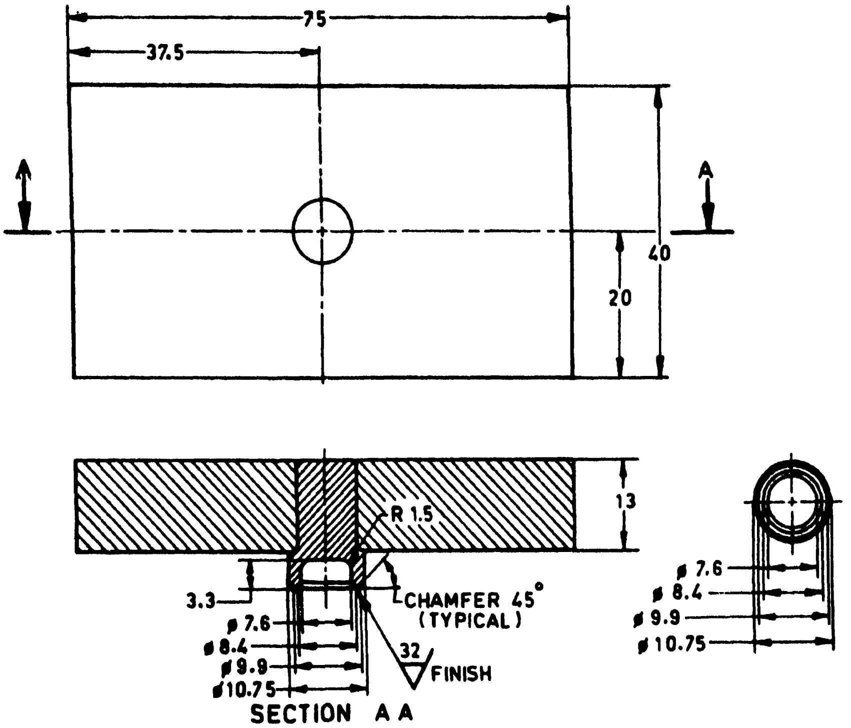
The test pieces shall be at least 50 mm wide and 200 mm long. At least three test values shall be obtained from each sample.

5 TIME INTERVAL BETWEEN MANUFACTURING AND TESTING

5.1 For all purpose, the minimum time between manufacturing and testing shall be 16 h.

5.2 For non-product tests, the maximum time between manufacturing and testing shall be 4 weeks and for evaluations intended to be comparable, the tests, as far as possible, should be carried out after the same time interval.

5.3 For product tests, whenever possible, the time between manufacturing and testing should not exceed



NOTES
1 All sharp edges to be removed.
2 Button to be press fit in plate.

All dimensions in millimetres.

FIG. 2 LOAD BUTTON ASSEMBLY

3 months. In other cases tests shall be made within 2 months of the date of receipt by the customer.

6 CONDITIONING OF TEST PIECES

Condition the test pieces at 27 ± 2°C and 65 ± 2 percent relative humidity for 48 hours prior to testing.

7 PROCEDURE

7.1 Place the base plate on the platform of the testing machine and place the test piece on the base plate. If the sample of material to be tested has an unbalanced coating, the side having the thicker coating shall be facing upward.

7.2 Place the load button of the machine onto the test piece so that the recess of the button, as shown in Fig. 2, is in contact with the test piece and is in a plane normal to that of the test piece. The circumference of the load button shall be at least 12 mm from any edge of the test piece. Apply the force to the button at the rate of approximately 0.08 mm/s until the shear yield point or maximum deflection of the dial pointer is reached, whichever is the lesser. Record the force required to crush the test piece. Repeat the procedure at least twice more on a new area of the test piece at least 12 mm away from other test areas and at least 12 mm from any edge.

7.3 Fabrics crushing can readily be detected by stretching the test piece. The fabric will have noticeably less resistance to stretching for the damaged areas when compared with the undamaged areas.

8 TEST REPORT

The test report shall include the following particulars:

a) Reference to this test method;

b) Identification of test pieces;

c) Conditioning period and temperature;

d) Number of test pieces tested; and

e) Force required to crush the coating or the fabric in the test piece, whichever occurs first.

METHODS OF TEST FOR COATED AND TREATED FABRICS

PART 14 LOW-TEMPERATURE IMPACT TEST

[*Source* : **IS 7016 (Part 14) : 1987**]

This prescribes a method for evaluation of rubber materials or fabrics coated therewith subjected to low temperature flexing with impact under well-defined conditions of striker speed. The response is largely dependent of effects of low temperatures, such as, crystallization, incompatibility of plasticizer or the inherent short term behaviour of the material itself. Data obtained by the method may be used to predict the product behaviour in applications where the conditions are similar to those specified in the method.

The method has been found useful for specification and development purposes, but it does not necessarily indicate the lowest temperature at which the material may be used.

1 SCOPE

It prescribes procedure for determining the lowest temperature at which fabrics coated with rubber or plastics shall not exhibit fractures or coating cracks when subjected to specific impact conditions.

2 APPARATUS

2.1 Test Piece Clamps and Striking Arm

The test piece clamps shall be designed to hold the test piece or pieces as a cantilever beam. Each individual test piece shall be held firmly and securely in the clamps. The striking edge shall move relative to the test piece(s) along a trajectory normal to the upper surface at a linear speed of 1.8 to 2.1 m/s at impact and during at least the following 6 mm of travel. In order to maintain this velocity consistently within the heat-transfer medium, the striking arm shall be positively driven. It may be necessary in some cases to reduce the number of test pieces tested at one time (*see* Annex A).

2.1.1 The striking edge shall have a radius of 1.6 ± 0.1 mm. The striking arm and test piece clamps shall have a clearance at and immediately following impact in accordance with the dimensions listed in Table 1.

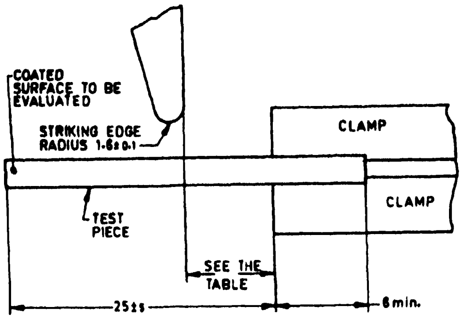
Table 1 Clearance of Striking Arm and Test Piece Clamps

Thickness of test Pieces, mm	Required Clearance, mm
1.65 to 2.15	6.4 ± 0.3
1.05 to 1.64	5.7 ± 0.3
0.55 to 1.04	5.2 ± 0.3
0.10 to 0.54	4.8 ± 0.3

NOTES

1 The dimensional requirements may be obtained by fabricating an adjustment plate or individual plates to fit the test piece holder illustrated in Fig. 1.

2 Apparatus for this test may have any type of activation, provided that it meets the dimensional and velocity requirements given above and in 2. If the striker is electrically driven, a means of controlling the voltage may be needed to control the speed when testing light gauge material.



All dimensions in millimetres.

FIG. 1 TEST PIECE HOLDER AND STRIKER

2.2 Insulated Tank

2.3 Heat Transfer Medium

Any liquid heat-transfer medium that remains fluid at the test temperature and which does not appreciably affect the materials being tested may be used.

CAUTION — Where a flammable or toxic solvent is used as the cooling medium, the customary precautions in handling, such as material shall be exercised.

2.3.1 Methanol is the recommended heat-transfer medium for rubber.

NOTE — The following materials have been used down to the indicated, temperatures:

Dow Corning 200 fluids:	
a) Kinematic viscosity 5 mm²/s	- 60°C
b) Kinematic viscosity 2 mm²/s	- 76°C
Methanol	- 90°C
Dichlorodifluoromethane	- 120°C

When dichlorodifluoromethane refrigerant is used, it shall be cooled below its boiling temperature of - 29.8°C before being transferred from the cylinder to the tank of the testing machine.

2.4 Stirrer – to provide thorough circulation of the heat-transfer medium.

2.5 Temperature Control (Automatic or Manual) - for controlling the temperature of the heat-transfer medium to within ± 0.5°C of the desired temperature.

2.5.1 Powdered solid carbon dioxide (dry ice), liquid nitrogen or liquid carbon dioxide are recommended for lowering the temperature. An electric immersion heater is required for raising the temperature.

2.6 Thermocouple

With associated temperature indicator graduated in 1°C divisions and having a range suitable for the temperature at which the tests are to be made. The thermocouple shall be constructed of copper-constantan wire between 0.2 mm and 0.5 mm in diameter and shall be fusion-bounded at the junction. It shall be located as near the test piece as possible.

NOTE — A thermometer may be used if it is shown to be in agreement with the specified thermocouple.

3 TEST PIECES

3.1 The test piece shall be die punched. It shall be 6.4 ± 0.5 mm wide. All test pieces shall be cut with the longer dimensions parallel to the lengthwise direction of the coated fabric unless otherwise specified.

3.2 A minimum of 6 mm of the test piece shall be held in the clamps, and the length extending from the clamp shall be 25 ± 5 mm.

NOTE — Sharp dies shall be used in the preparation of test pieces for this test if reliable results are to be obtained. Light honing of the cutting edges with a jeweller's honing stone may be carried out daily.

4 TIME INTERVAL BETWEEN MANUFACTURING AND TESTING

4.1 For all test purposes, the minimum time between manufacturing and testing shall be 16 h.

4.2 For non-product tests, the maximum time between manufacturing and testing shall be 4 weeks and for evaluations intended to be comparable the test, as far as possible, should be carried out after the same time-interval.

4.3 For product tests, whenever possible, the time between manufacturing and testing should not exceed 3 months. In other cases, tests shall be made within 2 months of the date of receipt by the customer.

5 CONDITIONING OF TEST PIECES

5.1 The test pieces shall be conditioned at 27 ± 2°C and 65 ± 2 percent relative humidity for at least 3 h prior to testing.

6 PROCEDURE

6.1 Prepare the tank (2.2) and bring the apparatus to the desired temperature. This may be accomplished by placing a suitable amount of solid carbon dioxide (dry ice) in the tank and slowly adding the heat-transfer medium until the tank is filled within 50 mm of the top. During the test, the temperature of the bath may be maintained constant by judicious addition of small quantities of dry ice.

NOTE — The desired temperature may also be obtained by filling the tank with the heat-transfer medium and lowering the temperature by the addition of liquid carbon dioxide controlled by a solenoid actuated with an associated temperature control Where temperatures below that obtainable with dry ice or liquid carbon dioxide are required, liquid nitrogen may be used.

6.2 Determine the thickness of the test pieces in accordance with the method prescribed in IS 7016 (Part 1) : 1982 'Methods of test for coated and treated fabrics: Part 1 Determination of roll characteristics (*first revision*)'given in Section D/31.1.

6.3 Mount the test pieces in their holder and immerse them for 3.0 ± 0.5 min at the desired temperature. The side to be evaluated shall face toward the striking arm unless otherwise specified.

6.4 After immersion for the specified time at the test temperature, record the temperature and deliver a single impact.

6.5 For each test, check the speed of the striker, which shall be between 1.8 and 2.1 m/s (*see* Annex A).

6.6 After removing the test pieces from the tank, examine each test piece to determine whether or not it has failed. Failure is defined as any fracture or crack visible in the coating when examined under a 5 X magnifier. Bend the test piece to an angle of 180° around a 6 mm diameter mandrel in the same direction as the bend caused by the impact prior to examining it under the 5 X magnifier.

6.7 Use new test pieces for each test temperature.

NOTE — For routine testing of all coated fabrics, subject the five test pieces to the impact test at a specified temperature as stated in the relevant material specification

6.8 For compliance with this method, no test piece shall fail at the specified temperature.

7 TEST REPORT

The test report shall include the following particulars:

a) Reference to this test method;

b) Identification of the coated fabric;

c) Temperature at which the test pieces were tested;

d) Type of testing apparatus used;

e) Conditioning temperature, humidity and period;

f) Length of time test pieces were immersed;

g) Number of test pieces tested;

h) Speed of striker at impact;

j) Behaviour of individual test pieces; and

k) Thickness of the coated fabric.

ANNEX A

(*Clauses* 2.1 *and* 6.5)

SPEED CALIBRATION OF THE SOLENOID-ACTUATED LOW TEMPERATURE IMPACT TESTER

A-1 SPEED CALIBRATION PRIOR TO TESTING

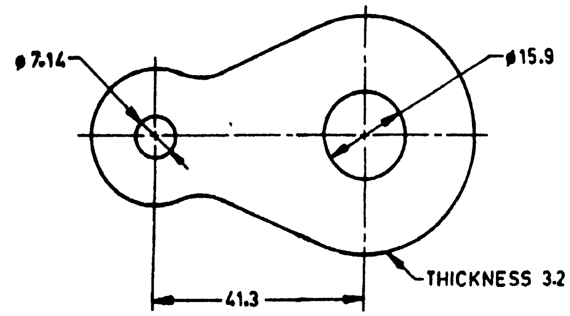
A-1.1 Principle

Measurement of the height *h* to which a steel ball, suspended on the striker mechanism of the tester, rises after the striker has had its upward motion halted by contact with a mechanical stop. Acceleration of the ball in such a manner that the low governing a freely falling body applies.

A-1.2 Procedure

A-1.2.1 *Securing Ball Support*

Remove either one of the nuts that fasten the striking bar guide rods to the solenoid armature yoke. Place the small hole of the ball support (*see* Fig. 2) over the guide rod and replace and secure the nut.



All dimensions in millimetres

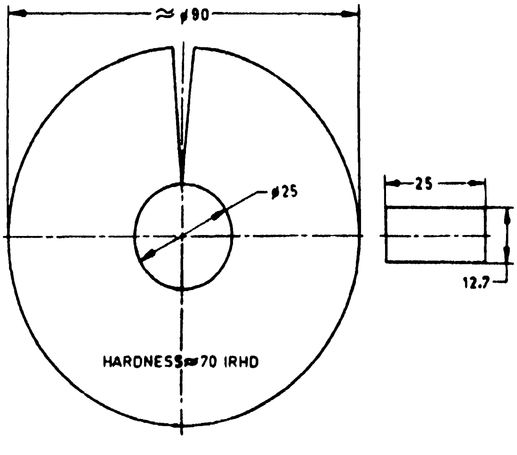
FIG. 2 BALL SUPPORT

A-1.2.2 *Adjusting Stroke of Striker*

Remove the metal guard from around the solenoid Spread open the rubber bumper (*see* Fig. 3) and insert it around the armature. Replace the solenoid guard. Insert a typical test piece into the specimen holder of the tester. Raise the striking mechanism by hand until the end of the stroke is reached. It is essential that, with the striking mechanism raised to its maximum height, the striker bar of the tester is in contact with the test piece but that the bar is not in contact with the test piece, the rubber bumper shall be removed and replaced by a thinner bumper. Conversely, if the striker bar moves into the plane of the test piece, the bumper shall be replaced by a thicker one.

A-1.2.3 *Placement of Ball and Measuring Tube*

Place 19 mm diameter steel ball on the ball holder (In theory, the upward flight of the ball is independent of the mass of the ball. However, if the mass is too large, the motion of the striker bar may be impeded). Clamp a glass or clear plastic tube with a minimum inside diameter of 25.4 mm in a vertical position directly over the ball. The tube should contain a scale divided into 5 mm intervals. The zero position on the scale should be aligned with the top of the ball when the ball is at the top of the stroke of the striker mechanism.



All dimensions in millimetres

FIG. 3 RUBBER BUMPER

A-1.2.4 *Measurement and Calculation*

With the tester equipped as described above and devoid of test pieces and immersion medium, actuate the solenoid and read the ball height to the nearest 5 mm. Make at least five measurements. Average all results and convert the average to metres. Determine the striker speed V, in metres per second, from the following equation :

$$V = \sqrt{2gh}$$

where

g = acceleration due to gravity, in metres per second squared (= 9.8 m/s^2); and
h = average ball height, in metres.

NOTE — Calibration measurements should be made with the tester supported on a non-resilient surface, such as a laboratory bench or concrete floor. Resilient mountings tend to absorb some of the striker energy causing low ball height values.

A-2 SPEED CALIBRATION DURING TESTING

A-2.1 With the tester equipped with ball support, ball and measuring tube (*see* **A-1**), but without the rubber bumper (tester in normal operating condition) and devoid of test pieces and immersion medium, actuate the solenoid and read the ball height to the nearest 5 mm. Make ten measurements. From the lowest and highest ball height readings, determine the range in striker speed, using the equation in **A-1.2.4**. This range is termed range of speed at the top of the stroke.

A-2.2 With the tester equipped as described in **A-2.1**, but also with test piece(s) and immersion medium, conduct the brittleness test as described in **6**. Read the ball height each time the solenoid is actuated. Convert the ball height to speed as shown in **A-1.2.4**. If the speed lies within the predetermined range or speed at the top of the stroke, the test should be considered valid. If the speed lies outside of the predetermined range, the test is invalid and should not be reported. Should successive tests be invalid, adjustments should be made to bring the speed at the top of the stroke within the acceptable, predetermined range. This may be accomplished by reducing the number of test pieces tested per impact.

A-2.3 The following example typifies the entire speed calibration procedure for solenoid-actuated testers:

a) Using the procedure specified in **A-1**, the striker speed at the point of impact of a tester devoid of test pieces and immersion medium was found to be 1.9 m/s. This speed is within the specified limits of **7.4**.

b) Using the procedure in **A-2.1**, with the tester devoid of test pieces and immersion medium, the range of striker speeds at the top of the stroke was found to be 2.5 to 2.7 m/s. This range becomes the acceptable range for this series of tests. The acceptable range should be established each time the striker speed at the point of impact is determined (*see* **A-1**).

c) Using the procedure of **A-2.2**, with the tester containing a test piece(s) and immersion medium, the speed at the top of stroke during the first, solenoid actuation was found to be 2.5 m/s. The speed is within the acceptable range and the test is valid.

d) The speeds at the top of the stroke during the second and third solenoid actuations were found to be 2.4 and 2.3 m/s, respectively. These speeds were outside of the acceptable range and both tests were invalid.

e) Adjustments were made to increase the speed at the top of the stroke, using the procedures given in **A-2.2**.

f) The speeds at the top of the stroke during the fourth and all subsequent solenoid actuations were found to lie between 2.5 and 2.7 m/s. The results of ail these tests were valid.

SECTION E

BIOCHEMICAL TESTS

DETECTION AND ESTIMATION OF DAMAGE IN COTTON YARN, CORDAGE AND FABRICS DUE TO MICRO-ORGANISMS

(*Source* : **IS 1815 : 1985** *and* **IS 1316 : 1984**)

Cotton yarn cordage are liable to be attacked and damaged by micro-organisms, such as bacteria and fungi, while in transit, in storage or in use. The deterioration is promoted by climatic conditions prevalent in tropical and subtropical countries.

Moisture is essential for the development and growth of micro-organisms, the amount of moisture required being dependent upon the type of organism. Thus fungi usually develop when the relative humidity of the environment approaches about 75 percent, and the growth is rapid when the relative humidity is above 85 percent. Bacterial, on the other hand, are active only when the substrate on which they are present is itself wet.

Fungi may appear as fine downy growth or as dark spots or stains causing discolouration of yarn or cordage as the case may be. The isolated regions of mould growth may show considerable tendering while the rest of the material (except when not weathered outdoors) may indicate little or no tendering. If the yarn or cordage had been in contact with soil or had been contaminated with it and then exposed to dampness, the entire material may show rapid and uniform tendering.

The degree of growth of micro-organisms as well as their tendering effect may differ widely even in the immediate neighbouring areas in the yarn or cordage. It is, therefore, not feasible to submit the results of tests prescribed in this test method to statistical analysis.

1 SCOPE

It prescribes a method for the detection and estimation of damage in cotton yarn, cordage and fabrics due to micro-organisms.

2 SAMPLING

2.1 Lot

The quantity of cotton yarn, cordage or fabric purported to be of one definite type and quality delivered to a buyer against one despatch note shall constitute a lot.

2.2 Sample for the test shall be selected so as to be representative of the lot. Samples drawn in accordance with the material specification or as agreed to between the buyer and the seller shall be taken as representative of the lot.

2.3 The sample shall be first visually examined against light for the presence of microbial growth like isolated dark portions, stains or discolouration; all the portions showing microbial growth shall be clearly marked.

2.4 The sample shall also be examined under an ultraviolet lamp having a *Blackwoodfilter* with peak output at 365 mm for the presence of any flourescent spots which shall be clearly marked.

NOTE — The presence of fluorescence is always not related to the microbial attack or the absence of it does not exclude the possibility of microbial attack.

3 TEST SPECIMENS

From the marked portions of the yarn or cordage draw at random 10 pieces each not less than 10 cm long. In case of fabrics, draw at random 10 test specimens each 2.5 cm × 2.5 cm in size. These shall constitute the test specimens for the purpose of **5.1.1**, **5.1.2** and **6.1.1**. Keep the test specimens in a humid chamber (*see* Note) with relative humidity above 85 percent at room temperature for 8 to 10 days. (For a humid chamber a large desiccator with water kept at the bottom may suffice.).

NOTE — If the marked portion as in 2.3 and 2.4 of the sample in the lot is showing visible patches of stains or discolouration, the specimens drawn as in 3 may be directly studied as in 5.1.1 without keeping in a humid chamber.

4 REAGENTS

4.1 Quality of Reagents

4.1.1 Unless specified otherwise, 'pure chemicals' shall be employed in the tests and distilled water shall be used where the use of water as a reagent is intended.

NOTE — 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the test results

4.2 The following reagents shall be used.

4.2.1 *Lactophenol Solution* — Prepared by dissolving 100 g phenol in 100 ml water and adding 100 ml each of glycerine and lactic acid to the solution.

4.2.2 *Cotton Blue Solution* — Prepared by making a saturated solution (about 25 ml) of cotton blue (old colour index number 707) (new colour index number 51190) in 95 percent alcohol and adding 10 ml of glycerine and 80 ml of water to 10 ml of this solution.

4.2.3 *Cotton Blue-Lactophenol Solution* — Prepared by mixing equal volumes of saturated aqueous cotton blue and lactophenol solutions.

4.2.4 *Sodium Hydroxide* — (18 percent *m/v*) prepared by dissolving 18 g sodium hydroxide pellets in 80 ml distilled water, allowing it to cool and finally making the volume to 100 ml.

4.3 Apparatus

4.3.1 Microscope with magnification range of 50 to 500.

5 DETECTION OF DAMAGE

5.1 Procedure

5.1.1 Unravel five to six yarns from the test specimens as drawn in 3.1. Tease them gently on a glass slide to separate individual fibres. Treat the fibres with a few drops of cotton blue-lactophenol solution for 1 to 2 minutes. Remove the colour from the surface of the fibres by treating them with lactophenol solution. Prepare at least 10 slides from these fibres.

5.1.2 Take a slide and examine it under a microscope at 100 to 500 magnification and compare the fibres with the undamaged fibre (*see* Fig. 5) Presence of the following signs indicates that the fabric has been damaged by microbial attack:

a) incisions or cracks on the cuticle, of the fibre (*see* Fig. 2);

b) damage to primary and secondary walls of the fibre from cuticle inwards (*see* Fig. 3);

c) hyphae within the lumen (*see* Fig. 4); and

d) indentation or serrations of the fibres from the cuticle inwards, that is, towards the lumen (*see* Fig. 5 and 6).

5.1.3 Similarly examine other slides.

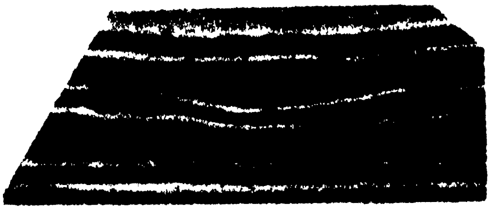


FIG. 1 UNDAMAGED COTTON FIBRE

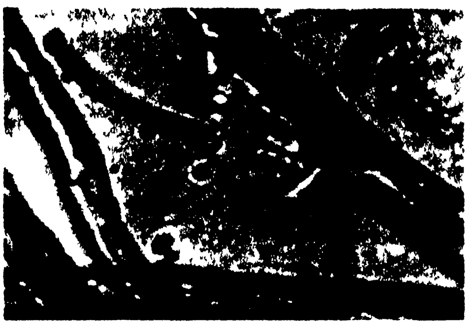


FIG. 2 COTTON FIBRE SHOWING INCISIONS OR CRACKS ON ITS CUTICLE

6 EXTENT OF DAMAGE

6.1 Procedure

6.1.1 *Extrusion Test*

Take one test specimen as drawn in 3 and prepare the individual fibres as in 5.1.1. Take a clean glass slide and place a drop of 18 percent NaOH on it. Place a bundle of fibres on a linoleum pad and cut off a small portion of the fibres approximately 0.2 mm in length with a sharp blade. Immerse the cut fibres in the alkali for about 60 seconds and examine under the microscope at 250 magnification and note down the number of dumbell shaped, funnel shaped and extrusionless fibres. Examine about 300 fibres and 10 slides in all.

6.1.2 Undamaged fibres show dumbell shape, and damaged fibres swell width-wise without showing any characteristic dumbell shape; some damaged fibres show roughly funnel shaped ends.

6.1.3 Fibres of 0.2 mm length can be conveniently cut with the help of two razor blades held together by a

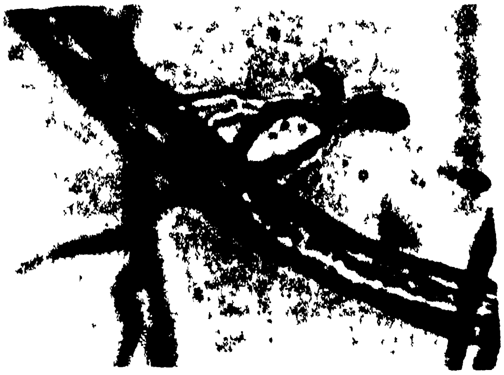


FIG. 3 COTTON FIBRE SHOWING DAMAGE TO ITS PRIMARY AND SECONDARY WALLS FROM THE CUTICLE INWARDS

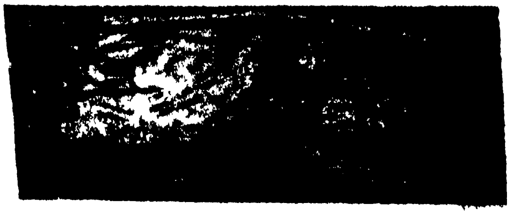


FIG. 4 COTTON FIBRE SHOWING FUNGAL INFECTION - HYPHAE AND SPORES INSIDE AND LUMEN

FIG. 5 COTTON FIBRE SHOWING MODERATE BACTERIAL DAMAGE

FIG. 6 COTTON FIBRE SHOWING SEVERE BACTERIAL DAMAGE

holder and then cutting the specimen, the fibres in between the two blades to be taken for examination.

6.1.4 Mechanically damaged fibres also do not show any characteristic dumbell shape and may add to the damage due to microbial attack, but their contribution to damage is negligible.

6.2 Calculate the percentage of dumbell shaped (a) funnel shaped (b) and extrusionless fibres (c) as examined in **6.1.1**. Obtain the quality figure as follows:

$$\text{Quality figure} = \frac{(a)}{1} + \frac{(b)}{2} + \frac{(c)}{3}$$

6.2.1 If a quality figure in **6.2** is less than 75, then report the sample as damaged. The quality figure may also include damage due to mechanically damaged fibres.

7 REPORT

The report shall include the following information:

a) Type of material,
b) Damaged/undamaged, and
c) Number of specimens tested.

TESTING COTTON FABRICS FOR RESISTANCE TO ATTACK BY MICRO-ORGANISMS

(*Source* : **IS 1389 : 1984)**

Cotton fabrics are liable to deterioration by the action of micro-organisms. Since they are often stored, transported and used under conditions favourable for the growth of micro-organisms, various protective treatments have been developed and their number is constantly increasing.

For different accelerated mildew infection methods and a soil burial method for testing cotton fabrics for resistance to attack by micro-organisms have been prescribed in this standard. The accelerated mildew infection methods are the humidity chamber method, pure culture method, mixed culture method and *Aspergillus niger* method. The humidity chamber method is intended for determining qualitatively the susceptibility of the fabric to the growth of micro-organisms associated with attack on cellulose. The pure culture and mixed culture methods are intended for testing quantitatively the resistance of the fabric to fungal attack by infecting the fabric with micro-organisms capable of destroying cellulose. The *Aspergillus niger* method is intended for assessing the resistance of waterproofed fabrics to the fungus *Aspergillus niger*, typical of those capable of destroying waterproofness. The soil burial method is intended for assessing the behaviour of the fabric under conditions of contact with damp soil for a long period.

Two alternative methods for determining the waterproofness of fabric have been provided, namely, the method for measuring water absorption and penetration in water-resistant fabrics (permeable to air) by Bundesmann type apparatus, as laid down in IS 392 : 1975 (*see* section C-1/12) and the static pressure head test as laid down in IS 7940 : 1976 (*see* section C-1/14). In the method prescribed in IS 392 : 1975 (*see* section C-1/12), the specimen under test is subjected to falling water drops simulating tropical rain of controlled intensity and to a rubbing action on the under surface; the assessment is made by determining: (a) the resistance to actual wetting as measured by the increase in mass of the specimen, and (b) the extent to which the specimen resists passage of water under the prescribed conditions of test. In the static pressure head test laid down in IS 7940 : 1976 (*see* section C-1/14) the test specimen is subjected to a constant hydrostatic pressure and the leakage of water through the specimen is measured.

Cultures of the organisms prescribed in this method for the test can be obtained from the Defence Materials and Stores Research and Development Establishment, Post Box No. 320, Kanpur 208013. To facilitate supply, the culture numbers as set out below may also be mentioned:

Micro-organism	*Kanpur Culture No.*
Aspergillus niger	51
Chaetomium globosum	6
Rhizopus Stolonifer	39
Memnoniella echinata	119
Helminthosporium sp	27
Pullularia Pullulans	45
Myrothecium verrucaria	159
Aspergillus japonicus	185
Curvularia Lunata	362
Penicillium pinophilum	364

The methods here can also be used for evaluating preservatives or treatments designed to protect cotton fabrics from damage by micro-organisms. In such cases, the preservative or the treatment has to be applied to a uniformly good quality cotton fabric by the procedure recommended by the supplier or the originator, and the treated fabric then tested.

1 SCOPE

It prescribes methods for evaluating cotton fabrics for resistance to attack by micro-organisms.

2 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

2.1 The tests shall be carried out under the conditions laid down in the respective test procedures. However, the specimens for breaking load testing shall be conditioned and tested in the standard atmosphere at 65 ± 2 percent relative humidity and 27 ± 2°C temperature (*see* IS 6359 : 1971 'Method of conditioning of textiles').

2.2 When the specimens have been left in such an atmosphere for 24 hours in such a way as to expose, as far as possible, all portions of the specimens to the atmosphere, they shall be deemed to have reached moisture equilibrium.

3 SAMPLING

3.1 Lot

The quantity of similar cotton fabric delivered to a buyer against one despatch note shall constitute a lot.

3.2 Samples shall be drawn so as to be representative of the lot. Samples drawn in accordance with the material specification or as agreed to between the buyer and the seller shall be taken as representative of the lot.

3.3 Take a sufficiently long piece (*see* Note 1) from each sample selected and mark it to identify it as a test sample. Similarly take a sufficiently long piece from the basic fabric (*see* Notes 2, 3 and 4) and mark it to identify it as the control sample.

NOTES

1 The total length of the test samples will depend on their width, but it should be sufficient for the number of test specimens required for **4.1**, **4.2**, **4.3**, **4.4** and **5**.

2 The length of the control sample will depend on its width, but it should be sufficient for the number of control specimens required for **4.1**, **4.2**, **4.3**, and **5**.

3 If an authentic sample of the basic fabric is not available, a fabric similar in construction to the one under test and free from size and finish should be used.

4 If it is known that the fabric under test has not been treated with a preservative, a sufficiently long piece from a well-scoured cotton fabric shall be taken as the basic fabric. The mass/m² of this fabric shall not vary by more than 20 percent of the mass of the fabric under test.

5 If information as to whether the fabric was treated with a preservative containing copper or mercury or both is not available, the fabric should be tested for the presence of copper and mercury by the usual chemical tests.

4 ACCELERATED MILDEW INFECTION METHODS

4.1 Humidity Chamber Method

4.1.1 *Apparatus*

4.1.1.1 *Humidity chamber* – with inside measurements 70 cm × 80 cm × 70 cm, lined on the inside with a non-corrosive material, and provided with shelves, arrangements to maintain relative humidity of 98 ± 2 percent at 30 ± 2°C and, preferably, a fan for air circulation.

4.1.1.2 *Petri dishes* – 12, each 15 cm in diameter, without cover.

4.1.2 *Test Organisms* – Cultures of the following organisms :

a) *Aspergillus niger*,
b) *Chaetomium globosum*,
c) *Rhizopus stolonifer*,
d) *Memnoniella echinata*,
e) *Helminthosporium sp*, and
f) *Pullularia pullulans*.

4.1.3 *Procedure*

4.1.3.1 From the test samples, cut at random 6 test specimens, each of size 10 cm × 5 cm, with their longer sides parallel to warp threads.

4.1.3.2 Prepare, in the manner prescribed in Annex A, mixed suspension of the spores of the test organisms prescribed in **4.1.2**.

4.1.3.3 Take 6 petri dishes and place 1 test specimen in each dish. Inoculate each specimen (*see* **4.1.3.4**) with 2 ml of the mixed spore suspension. Lay the petri dishes on the shelves and leave them for 14 days inside the humidity chamber maintained at 98 ± 2 percent relative humidity and 30 ± 2°C temperature. At the end of the period, remove the specimens and evaluate the degree of fungal growth on each specimen in terms of ratings as given in Table 1.

4.1.3.4 From the control sample, cut at random 6 control specimens, each of size 10 cm × 5 cm with their longer sides parallel to warp threads. Side by side with the test on test specimens, test the control specimens according to the procedure set out in **4.1.3.3** for test specimens.

Table 1 Degree of Fungal Growth

(*Clauses* 4.1.3.3 *and* 4.4.3.3)

Symbolic Rating (1)	State of Growth of Micro-Organisms (2)	Rating in Terms of Resistance (3)
-	No growth	Good
+	Slight growth (area of growth less than one-fourth)	Fair
++	Moderate growth (area of growth more than one-fourth but less than half)	Poor
+++	Heavy growth (area of growth more than half)	Very poor

4.1.3.5 The rating for the control specimens shall be 'very poor', that is, the control specimens should show heavy mould growth; if not, the test shall be considered inconclusive and shall be repeated.

4.1.3.6 Report the rating in terms of resistance of the fabric under test to attack by micro-organisms.

4.2 Pure Culture Method

4.2.1 *Apparatus*

4.2.1.1 *Petri dishes* – 15, each 15 cm in diameter.

4.2.1.2 *Atomizer* – 10-ml capacity.

4.2.2 *Test Organism* – Culture of *Chaetomium globosum*.

NOTE — If the material under test has been treated with a preservative containing mercury or copper or both (*see* Note 5 under **3.3**), culture of *Myrothecium verrucaria* should be used instead of *Chaetomium globosum*.

4.2.3 *Test Medium* – Mix together the following in 1 000 ml of distilled water and sterilize with steam at a pressure of 108 kPa (1.1 Kg/cm^2) for 20 minutes :

Ammonium nitrate	3.00 g
Potassium dihydrogen phosphate	0.25 g
Magnesium sulphate	0.25 g
Potassium chloride	0.25 g
Agar-agar	5.00 g

NOTES

1 Only pure chemicals shall be used for preparing the medium 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the results of test.

2 The *p*H of the medium should be 6.4.

4.2.4 *Procedure*

4.2.4.1 From the test samples, cut at random 15 test specimens, each of size 27 cm × 6.5 cm, with their longer sides parallel to warp threads. Take 5 test specimens, condition them to moisture equilibrium in the standard atmosphere (*see* **2**) and determine the breaking load of each specimen by the method prescribed in IS 1969 : 1968 'Method for determination of breaking load and elongation at break of woven textile fabrics (*first revision*)' (*see* Section B-3/6). Find the average of all the values.

4.2.4.2 From the control sample, cut at random 10 control specimens, each of size 27 cm × 6.5 cm, with their longer sides parallel warp threads. Take 5 control specimens, condition them to moisture equilibrium in the standard atmosphere (*see* **2**) and determine the breaking load of each specimen by the method prescribed in IS 1969 : 1968. 'Method for determination of breaking load and elongation at break of woven textile fabrics (*first revision*)' (*see* Section B-3/6) Find the average of all the values.

4.2.4.3 Prepare, in the manner prescribed in Annex A, suspension of the spores of the test organism prescribed in **4.2.2**.

4.2.4.4 Out of the remaining 10 test specimens, take 5 specimens.

4.2.4.5 Sterilize the specimens in the manner prescribed in Annex B and with sterile instruments. Transfer them to 5 sterile petri dishes, each containing 50 ml of the test medium. Roll up the two ends of each specimen so that about 13 cm of its central portion is left exposed. Inoculate the exposed portion of each specimen under sterile conditions by spraying with 2 ml of the suspension prepared as in **4.2.4.3** by means of the atomizer. Incubate the specimens for 14 days at 98 ± 2 percent relative humidity and 30 ± 2°C temperature. At the end of the period, remove the specimens and wash them with cold water until they are free from agar. Dry the specimens in air, condition them to moisture equilibrium in the standard atmosphere (*see* **2**) and determine the breaking load of each by the method prescribed in IS 1969 : 1968 'Method for determination of breaking load and elongation at break of woven textile fabrics (*first revision*)' (*see* Section B-3/6) Find the average of all the values.

4.2.4.6 Leach the remaining 5 test specimens in the manner prescribed in Annex C and test them in the manner prescribed in **4.2.4.5**

4.2.4.7 Test the remaining 5 control specimens in the manner prescribed in **4.2.4.5**.

4.2.4.8 Calculate the loss in breaking load, percent, of the basic fabric on incubation (L) by the following formula:

$$L = \frac{100(a-b)}{a}$$

where

a = average breaking load value obtained as in **4.2.4.2**, and
b = average breaking load value obtained as in **4.2.4.7**.

If the value of L is less than 90 percent, the test shall be repeated.

4.2.4.9 Calculate in the manner prescribed in **4.2.4.8** the loss in breaking load, percent, of the fabric under test on incubation prior to leaching, equating to:

'a' the value obtained as in **4.2.4.1**, and
'b' the value obtained as in **4.2.4.5**.

NOTE — The fabric should be considered satisfactorily resistant to attack by micro-organisms if the value of L does not exceed 10 percent.

4.2.4.10 Calculate in the manner prescribed in **4.2.4.8** the loss in breaking load, percent, of the fabric under test on incubation after leaching, equating to:

'a' the value obtained as in **4.2.4.1**, and
'b' the value obtained as in **4.2.4.6**.

NOTE — The fabric should be considered satisfactorily resistant to attack by micro-organisms if the value of L does not exceed 10 percent.

4.2.4.11 Report the following :

a) Loss in breaking load, percent, of the basic fabric on incubation (*see* **4.2.4.8**);
b) Loss in breaking load, percent, of the fabric under test on incubation prior to leaching (*see* **4.2.4.9**); and
c) Loss in breaking load, percent, of the fabric under test on incubation after leaching (*see* **4.2.4.10**).

4.3 Mixed Culture Method

4.3.1 *Apparatus* – Same as in **4.2.1**.

4.3.2 *Test Organisms* – Cultures of the following organisms:

a) *Aspergillus japonicus*,
b) *Curvularia lunata*, and
c) *Penicillium pinopnilum*.

4.3.3 *Test Medium* – Same as in **4.2.3**.

4.3.4 *Procedure* – Follow the procedure prescribed in **4.2.4**, except that:

a) for the purpose of **4.2.4.3**, prepare (instead of a suspension of the spores of *Chaetomium globosum*) a mixed suspension of the spores of the test organisms prescribed in **4.3.2**; and
b) for the purpose of **4.2.4.5**, use (instead of a suspension of the spores of *Chaetomium globosum*) a mixed suspension as prescribed in (a) above.

4.4 *Aspergillus Niger* Method

4.4.1 *Apparatus*

4.4.1.1 *Petri dishes* – 6, each 15 cm in diameter.

4.4.1.2 *Atomizer* – 10-ml capacity.

4.4.2 *Test Organism* – Culture of *Aspergillus niger*.

4.4.3 *Procedure*

4.4.3.1 From the test samples, cut at random 9 test specimens in the form of 13 cm diameter discs.

4.4.3.2 Take 3 test specimens and determine their waterproofness in accordance with IS 392 : 1975 (*see* Section C-1/12), or IS 7940:1976 (*see* Section C-1/14).

If the waterproofness test in made as prescribed in IS 392:1975, determine for each specimen:

a) the percentage of absorption of water: and
b) the penetration, in millilitres, of water.

Find the average values.

If the waterproofness test is made as prescribed in IS 7940 : 1976 (*see* Section C-1/14) determine the leakage of water, in litres per square metre per hour. Find the average value.

4.4.3.3 Take 3 test specimens from the remaining and sterilize them in the manner prescribed in Annex B. Take 3 sterile petri dishes and put in each dish 10 ml of sterile water and filter paper of 10 cm diameter. With sterile instruments, transfer the specimens to the petri dishes.

Inoculate each specimen by spraying with 2 ml of the suspension of the spores of *Aspergillus niger* prepared according to Annex A by means of the atomizer. Incubate the specimens for 9 days at 98 ± 2 percent relative humidity and 30 ± 2°C temperature. At the end of the period, evaluate the degree of fungal growth on each specimen in terms of ratings as given in Table 1 (*see* **4.1.3.3**).

4.4.3.4 Dry the specimens in air and determine their waterproofness by the method chosen for the purpose (*see* **4.4.3.2**).

4.4.3.5 Leach the remaining 3 test specimens in the manner prescribed in Annex C and test them in the manner prescribed in **4.4.3.3** and **4.4.3.4**.

4.4.3.6 Report the results of the test in the form prescribed below:

	Unleached Fabric		*Leached Fabric, After Biological Test* (*see* **4.4.3.5**)
	Before Biological Test (*see* **4.4.3.2**)	After Biological Test (*see* **4.4.3.3** and **4.4.3.4**)	
a) Rating in terms of resistance to growth of *Aspergillus niger*			
b) Waterproofness:			
1) Absorption, percent of water and			
2) penetration, in ml, of water			
OR			
Leakage of water in litres per square metre per hour			

NOTE — If the waterproofness test has been made by the method prescribed in IS 392 : 1975 (*see* Section C-1/12) the fabric should be considered satisfactorily resistant to attack by micro-organisms provided that:

i) the ratings obtained as in **4.4.3.3** and **4.4.3.5** are good;

ii) the values for absorption, percent, obtained as in **4.4.3.4** and **4.4.3.5** do not exceed the corresponding value obtained as in **4.4.3.2** by more than 20 percent; and

iii) the values for penetration obtained as in **4.4.3.4** and **4.4.3.5** do not exceed the corresponding value obtained as in **4.4.3.2** by more than 10 ml.

If the waterproofness test has been made in accordance with the method prescribed in IS 7940 : 1976 (*see* section C-1/14), the fabric should be considered satisfactory resistant to attack by micro-organisms provided that:

a) the ratings obtained as in **4.4.3.3** and **4.4.3.5** are 'good', and

b) the values for leakage obtained as in **4.4.3.4** and **4.4.3.5** do not exceed the corresponding value obtained as in **4.4.3.2** by more than 0.6 litres per square metre per hour.

5 SOIL BURIAL METHOD

5.1 Test Soil

Prepare as prescribed in Annex D.

5.2 Procedure

5.2.1 From the test samples, cut at random 15 test specimens, each of size 27 cm × 65 cm with their longer sides parallel to warp threads. Take 5 test specimens and test them as given in **4.2.4.1**.

5.2.2 Take 5 out of the remaining 10 test specimens.

5.2.3 Put the test soil in five 500-ml beakers and bury 1 specimen in each beaker in such a way that the ends of the specimen are free (Except for the free ends, the rest of the specimen should be surrounded by 2.5 cm thick soil). Incubate the specimens at 98 ± 2 percent relative humidity and 30 ± 2°C temperature for 7 days, if the fabric under test is light in weight, and for 28 days, if the fabric under test is heavy in weight (*see* Note). At the end of the period, remove the specimens, wash them free from soil, dry them for 30 minutes at 50 to 60°C, condition them to moisture equilibrium in the standard atmosphere and determine the breaking load of each by the method prescribed in IS 1969 : 1968 (*see* Section B-3/6). Find the average of all the values.

NOTE — Fabrics weighing up to 300 g/m² should be considered as light fabrics and more than this limit be considered as heavier fabrics to decide about the time of incubation.

5.2.4 Leach the remaining 5 test specimens in the manner prescribed in Annex C and test them in the manner prescribed in **5.2.3**.

5.2.5 From the control sample, cut at random 10 control specimens, each of size 27 cm × 6.5 cm, with their longer sides parallel to warp threads. Take 5 specimens and test them as given in **4.2.4.2**.

5.2.6 Test the remaining 5 control specimens in the manner prescribed in **5.2.3**.

5.2.7 Calculate the loss in breaking load, percent, of the basic fabric on soil burial (L) by the following formula:

$$L = \frac{100(a-b)}{a}$$

where

a = average breaking load value obtained as in **5.2.5**, and

b = average breaking load value obtained as in **5.2.6**

If the value of L is less than 90 percent, the test shall be repeated.

5.2.8 Calculate in the manner prescribed in **5.2.7** the loss in breaking load, percent, of the fabric under test on soil burial prior to leaching, equating to:

'a' the value obtained as in **5.2.1**, and
'b' the value obtained as in **5.2.3**.

NOTE — The fabric should be considered satisfactorily resistant to attack by micro-organisms if the value of L does not exceed 10 percent.

5.2.9 Calculate in the manner prescribed in **5.2.7** the loss in breaking load, percent, of the fabric under test on soil burial after leaching, equating to:

'a' the value obtained as in **5.2.1**, and
'b' the value obtained as in **5.2.4**.

NOTE — The fabric should be considered satisfactorily resistant to attack by micro-organisms if the value of L does not exceed 10 percent.

5.2.10 Report the following:

a) Loss in breaking load, percent, of the basic fabric on soil burial (*see* **5.2.7**);
b) Loss in breaking load, percent, of the fabric under test on soil burial prior to leaching (*see* **5.2.8**); and
c) Loss in breaking load, percent, of the fabric under test on soil burial after leaching (*see* **5.2.9**).

ANNEX A

(*Clauses* 4.1.3.2, 4.2.4.3 *and* 4.4.3.3)

PREPARATION OF SPORE SUSPENSION*

A-1 CULTURE MEDIUM

A-1.1 Take about 250 g of potatoes, peel them off and cut them into slices. Weigh 200 g of the sliced potatoes, wash them in running tap water and place them in a beaker. Add 500 ml of distilled water and keep the contents at boil for 30 minutes. Filter the hot extract through a thin layer of absorbent cotton previously wetted with distilled water. Preserve the filtrate.

A-1.2 Take 25 g of agar, cut it into small pieces and boil, in the minimum quantity of distilled water necessary, till no solid agar is visible. Add 20 g of dextrose and mix it with the filtrate (*see* **A-1.1**). Make up the volume to 1 000 ml with hot distilled water. Adjust the *p*H of the culture medium to 6.4.

NOTE — To avoid solidification, the temperature of the culture medium should be kept above 45°C.

A-1.3 Put 5 ml of the culture medium into each of a number of 15 cm × 2 cm test tubes and plug them with non-absorbent cotton-wool. In an autoclave, sterilize the culture medium with steam at a pressure of 108 kPa (1.1 kg/cm^2) for 20 minutes. At the end of the period, remove the test tubes from the autoclave, place them in a slanting position and allow them to cool to harden the culture medium into slants.

A-2 SUB-CULTURE

A-2.1 Inoculate the slants in the test tubes with a well-sporulated culture of the test organism (*see* **4.1.2**, **4.2.2**, **4.3.2** and **4.4.2**) by means of a sterile needle. Incubate the slants for 7 days at 30 ± 2°C.

NOTE — At the end of this period, a heavy growth of the freshly sporulating test organism should be visible within the tubes.

A-3 PREPARATION

A-3.1 Add about 10 ml of sterile distilled water to freshly sporulating sub-culture of the test organism (*see* **A-2**) within the tubes. Bring the spores of the sub-culture into suspension by shaking or disturbing them gently with a sterile glass rod. Filter the suspension through a sterile muslin or similar fabric to remove particles of agar or fungal mycelium. Examine a drop of the sport suspension under a low-power microscope, and see whether 50 or more spores appear in the field.

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* If a mixed suspension of the spores of more than one test organism is to be prepared, the suspension of the spores of each test organism shall be prepared separately and the suspensions then mixed in equal volumes.

ANNEX B

(*Clauses* 4.2.4.5 *and* 4.4.3.3)

STERILIZATION IN METHYL ALCOHOL VAPOUR

B-1 Pack the specimens loosely in a desiccator of suitable size containing methyl alcohol and keep them for 24 hours (or longer) at room temperature (about 27°C). In the meantime, make another desiccator ready by sterilizing it with methyl alcohol vapour for a period of 12 hours at room temperature. Transfer the specimens from the first desiccator to the second with a pair of sterile tongs. Connect the second desiccator to a water pump through a cotton-wool filter and exhaust the desiccator at room temperature for 6 hours to remove traces of methyl alcohol. Bring the pressure in the desiccator to the atmospheric pressure by slowly letting in air through the cotton-wool filter.

ANNEX C

(*Clauses* 4.2.4.6, 4.4.3.5 *and* 5.2.4)

METHOD OF LEACHING

C-1 Place the specimen inside a glass jar with internal diameter of 9 cm. Through a capillary extending to within 0.6 cm of the bottom of the jar, allow water (with *p*H of not less than 6.0 and not more than 8.0 and at a temperature of 30 ± 2°C) to flow into it at the rate of 10 litres per hour. In this stream of water leach the specimen for 24 hours.

ANNEX D

(*Clause* 5.1)

PREPARATION OF TEST SOIL

D-1 Mix thoroughly:

a) a layer of good, sandy loam soil, 13 cm thick;
b) a layer of fresh cow-dung manure, 7.5 cm thick; and
c) a layer of finely chopped straw, 15 cm thick.

Allow the mixture to ferment for 2 months, turning it once a week and maintaining the moisture content at 22 to 25 percent on the total mass of the mixture. At the end of the period, put the resulting compost through 300-µm IS Sieve [*see* IS 460 (Part 1) : 1985 Specification for test sieves: Part 1 Wire cloth test sieves] and test it in the manner prescribed in **D-1.1** to **D-1.5**.

D-1.1 Take a light-weight cotton fabric weighing 240 to 255g/m^2 and draw from it 6 pieces, each to size 20 cm × 5 cm.

D-1.2 Take three pieces of the fabric and determine the breaking load of each by the method prescribed in IS 1969 : 1968 (*see* Section B-3/6). Find the average of all the values.

D-1.3 Bury the remaining 3 pieces of the fabric in the compost for 5 days. At the end of this period, remove the pieces from the compost and determine the breaking load of each by the method prescribed in IS 1969 : 1968 (*see* Section B-3/6). Find the average of all the values.

D-1.4 Calculate the loss in breaking load, percent, of the fabric after soil burial.

D-1.5 The soil shall be deemed to be suitable for the test if the loss in breaking load of the fabric, so determined, is 80 percent or more.

DETECTION AND ESTIMATION OF DAMAGE IN JUTE YARN, CORDAGE AND FABRICS DUE TO MICRO-ORGANISMS

(*Source* : **IS 2011 : 1984** *and* **IS 2010 : 1984**)

Jute yarn and cordage are liable to be attacked and damaged by micro-organisms, such as bacteria and fungi, while in transit, storage or use. The deterioration is promoted by climatic conditions prevalent in tropical and subtropical countries.

Moisture is essential for the development and growth of micro-organisms, the amount of moisture required being dependent upon the type of organism. Thus, fungi usually develop when the relative humidity of the environment approaches about 75 percent, and the growth is rapid when the relative humidity is above 85 percent. Bacteria, on the other hand, are active only when the substrate on which they are present is itself wet.

Fungi may appear as a fine downy growth or as dark spots or stains causing discoloration of the yarn or cordage. The isolated regions of mould growth may show considerable tendering while the rest of the material may indicate little or no tendering. If the yarn or cordage had been in contact with soil or had been contaminated with it and then exposed to dampness, the entire material may show rapid and uniform tendering.

The degree of growth of micro-organisms as well as their tendering effect may differ widely even in the immediate neighbouring areas in the yarn, cordage or fabric. It is, therefore, not practicable to submit the results of the test method to statistical analysis.

1 SCOPE

It prescribes methods for detection and estimation of damage in jute yarn, cordage and fabrics due to micro-organisms.

2 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

2.1 The specimens for breaking load testing shall be conditioned and tested in the standard atmosphere at 65 ± 2 percent relative humidity and 27 ± 2°C temperature (*see* IS 6359 : 1971 'Methods of conditioning of textiles' given in Section B-1/1).

2.2 When the specimens have been left in such an atmosphere, for 24 hours in such a way as to expose, as far as possible, all portions of the specimens to the atmosphere, they shall be deemed to have reached moisture equilibrium.

3 SAMPLING

3.1 Lot

The quantity of similar jute yarn or cordage, delivered to a buyer against one despatch note shall constitute a lot.

3.2 Samples for test shall be drawn so as to be representative of the lot. Samples drawn in accordance with the material specification or as agreed to between the buyer and the seller shall be taken as representative of the lot.

3.3 The samples shall be first visually examined for the presence of mould growth, indicated by isolated dark portions, stains, discoloration, etc; all the portions showing mould growth shall be clearly marked.

3.4 YARN AND CORDAGES

3.4.1 From the marked portions of the samples, draw at random 10 pieces, each not less than 10 cm in length. These shall constitute the test specimens for the purpose of **5.3** and **5.4**.

3.4.2 From the marked portions of the samples, draw at random 10 pieces, each of length not less than 1 m in the case of yarn and 25 cm in the case of cordage (*see* Note). These shall constitute the test specimens for the purpose of **6.1** and **6.2**.

NOTE — The individual yarn specimens may be carefully tied together at both ends immediately after being drawn from the samples so that their twist is not affected during subsequent handling.

3.4.3 From the unmarked portions of the samples, draw at random 11 pieces, each of length not less than 1 m in the case of yarn and 25 cm in the case of cordage. These shall constitute the control specimens for the purpose of **6.1** and **6.2**.

3.5 FABRICS

3.5.1 From the marked portions of the samples, draw at random 10 pieces, each 2.5 cm × 2.5 cm in size. These shall constitute the test specimens for the purpose of **5.3** and **5.4**.

3.5.2 From the marked portions of the samples, draw at random 11 pieces, each measuring 33 cm × 12.5 cm in size. Unravel yarns from both sides of each specimen so that the width of the specimens is 10 cm. These shall constitute the test specimens for the purpose of **6.1** and **6.2** (*see* Note under **3.5.3**).

3.5.3 From the unmarked and undamaged portions of the samples, draw at random 11 pieces, each 33 cm × 12.5 cm in size. Unravel yarn from both sides of each specimen so that the width of the specimens is 10 cm. These shall constitute the control specimens for the purpose of **6.1** and **6.2**.

NOTE — The test and control specimens should be drawn so that the length of all the specimens is in the direction of either warp or weft, preferably in the direction of warp.

4 QUALITY OF REAGENTS

4.1 Unless specified otherwise, pure chemicals and distilled water shall be used in tests.

NOTE —'Pure chemicals' shall mean chemicals that do not contain impurities which affect the test results

5 DETECTION OF DAMAGE

5.1 Apparatus

5.1.1 *Glass Slides* — 15 pairs.

5.1.2 *Microscope* — with a magnification range of 50 to 900.

5.2 Reagents

5.2.1 *Lactophenol Solution* – Dissolve 100 g of phenol in 100 ml of water and add to the solution 100 ml each of glycerine and lactic acid.

5.2.2 *Chlorazol Sky Blue* (*New Colour Index No. 24410*) *Solution* – 2.5 percent solution in distilled water.

5.2.3 *Acid Erythrosin* (*New Colour Index No.45430*) *Solution* – 1.0 percent solution in distilled water. Dilute one part of this solution with three parts of distilled water.

5.3 Detection of Fungal Damage

5.3.1 Take 5 test specimens drawn as in **3.4.1** or **3.5.1** and, in the case of cordage or fabric unravel single strands/ yarns from each specimen. Take 5 or 6 strands/ yarns from each specimen and tease them gently on a glass slide to separate individual fibres. Treat the fibres with a few drops of Chlorazol Sky Blue solution for 1 to 2 minutes.

5.3.2 Put about 50 ml of distilled water in a 125-ml conical flask and boil it briskly. Steam the fibres for 30 seconds by placing the slide on the mouth of the flask.

5.3.3 At the end of 30 seconds, remove the slide and blot off the excess Chlorazol Sky Blue solution with blotting paper.

5.3.4 Treat the fibres on the slide with a few drops of lactophenol solution. Following the procedure prescribed in **5.3.2** steam the fibres for 30 seconds. Remove the slide and blot off the excess lactophenol solution.

5.3.5 Mount the fibres on a separate slide with a few drops of lactophenol solution. If necessary, separate the fibres by teasing them apart gently. Cover them with a cover slip and examine a small portion of the aggregate under the microscope with a magnification of 50 to 500. Examine 5 slides in all.

5.3.6 If the slides show blue stained hyphae, report the lot to have been damaged by fungal attack.

5.4 Detection of Bacterial Damage

5.4.1 Take the remaining 5 test specimens drawn as in **3.4.1** or **3.5.1** and, in the case of cordage or fabric unravel single strands/yarns from each. Take 5 or 6 strands /yarns from each specimen and tease them gently on a glass slide to separate individual fibres. Treat the firbres with a few drops of acid erythrosin solution for 1 to 2 minutes.

5.4.2 Following the procedure prescribed in **5.3.2**, steam the fibres for 30 seconds. Remove the slide and blot off the excess acid erythrosin solution with a blotting paper. Wash the fibres on the slide several times with distilled water by adding a few drops of distilled water and blotting them off.

5.4.3 Mount the fibres on a separate glass slide with a few drops of distilled water. If necessary, separate the fibres by testing them apart gently. Cover them with a cover slip and examine a small portion of the aggregate under the microscope with a magnification of 500 to 900. Examine 5 slides in all.

NOTE — Both damaged and undamaged fibres will be stained red, but the presence of bacteria will be indicated by a comparatively deeper red stain.

5.4.4 If the slides show deep red stains, report the presence of bacteria in the material under examination.

6 ESTIMATION OF DAMAGE

6.0 Estimate the damage in the sample under test by the methods given in **6.1** and **6.2**.

NOTE — If the damage is not very great or if only a small quantity of samples is available for testing, only the method prescribed in **6.2** may be used.

6.1 Breaking Load Test

6.1.1 *Yarn Specimens*

Take 10 test specimens drawn as in **3.4.2** and condition them to moisture equilibrium in the standard atmosphere. Determine the breaking load of each specimen on a vertical type yarn strength testing machine at a rate of traverse of 30 cm/min and keeping the distance between the grips of the machine as 60 cm. Find the average of all the values.

NOTE — The breaking load of the individual test specimens may vary widely among themselves depending on the degree of tendering of each specimen.

6.1.2 *Cordage Specimen*

Take 10 test specimens drawn as in **3.4.2** and condition them to moisture equilibrium in the standard atmosphere. Determine the breaking load of each specimen on a vertical or horizontal type rope strength testing machine at a rate of traverse of 30 cm/min and keeping the distance between the grips of the machine as 12.5 cm. Find the average of all the values (*see* Note under **6.1.1**).

6.1.3 *Fabric Specimen*

Take 10 test specimens drawn as in **3.5.2** and condition them to moisture equilibrium in the standard atmosphere. Determine the breaking load of each specimen on a horizontal or vertical type strength testing machine, keeping the distance between the grips of the machine as 20 cm and at a rate of traverse of 45 cm/min. Find the average of all the values.

NOTE — The breaking load of the individual test specimens may vary widely among themselves depending on the degree of tendering of each specimen.

6.1.4 Determine as prescribed in **6.1.1**, **6.1.2** or **6.1.3** as applicable, the average breaking load of 10 control specimens out of eleven drawn as in **3.4.3** or **3.5.3**.

6.1.5 Calculate the loss in breaking load, percent, of the basic yarn, cordage or fabric after being damaged (L) by the following formula :

$$L = \frac{100(a-b)}{a}$$

where

a = average breaking load of the control specimens, and

b = average breaking load of the test specimens.

NOTE — If the value of L is more than 20 percent, the material should be declared as damaged. The degree of damage will increase with the increasing value of L.

6.2 Damage Count Test

6.2.1 *Reagents*

6.2.1.1 *Caustic Soda Solution* – 10 percent (*m/v*), in distilled water.

6.2.1.2 *Herzberg's reagent* – Dissolve 2 g of zinc chloride in 10 ml of water. Dissolve separately 2.1 g of potassium iodide and 0.1 g of iodine in 5 ml of water. Mix the two solutions thoroughly.

6.2.2 *Procedure*

6.2.2.1 Take the remaining one test specimen drawn as in **3.4.2** or **3.5.2**. If the lot consists of yarn, cut the specimen into small lengths. If the lot consists of cordage or fabric, unravel yarns from the specimen and cut them into small lengths. Tease the yarn pieces into individual fibres. Mix the fibres thoroughly and cut them into pieces of about 1 cm length. Immerse the cut fibres in 10 percent caustic soda solution for 3 minutes to wet them thoroughly. At the end of this period, remove the fibres from the alkali solution. Wash the fibres thoroughly with several changes of water and squeeze out the excess water by pressing them between pieces of filter paper. Dry the fibres in an air oven at a temperature not exceeding

100°C for a period not exceeding 10 minutes. Roll the dried fibres into a narrow wick and shred into small bits of about 0.5 to 1 mm length.

6.2.2.2 Take a glass slide and place on it a drop of Herzberg's reagent. With the help of a pair of dissecting needles put some portion of the fibres in the Herzberg's reagent. Carefully separate the individual fibres in the reagent with the help of the needles.

6.2.2.3 Boil briskly about 100 ml of distilled water in a conical flask of 250 ml capacity until a continuous stream of stream is produced. Then place the slide on the mouth of the flask and steam the fibres on it for exactly 1½ minutes. At the end of this period, remove the slide.

6.2.2.4 Cover the fibres with a cover slip and examine the slide under the microscope with a magnification of 80.

NOTE — Damaged fibres appear more or less straight whereas undamaged fibres show a characteristic spiral formation (*see* Fig. 1 and 2). The photomicrographs in Fig. 1 and 2 are taken with a magnification of 200, though a magnification of 80 is sufficient for the purpose of this test.

6.2.2.5 Count separately the number of damaged and undamaged fibres and calculate the damage count of the fibres on the slide by the following formula:

$$\text{Damage count} = \frac{a}{a+b} \times 100$$

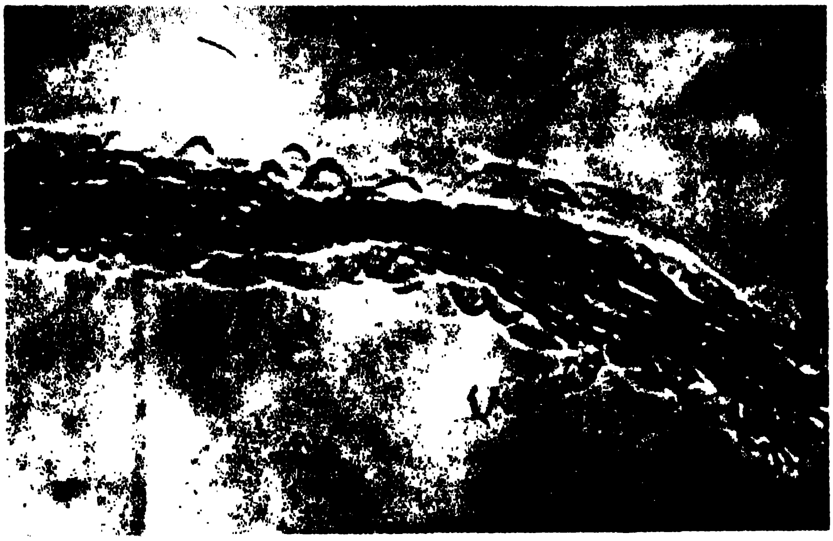


FIG. 1 UNDAMAGED JUTE FIBRE

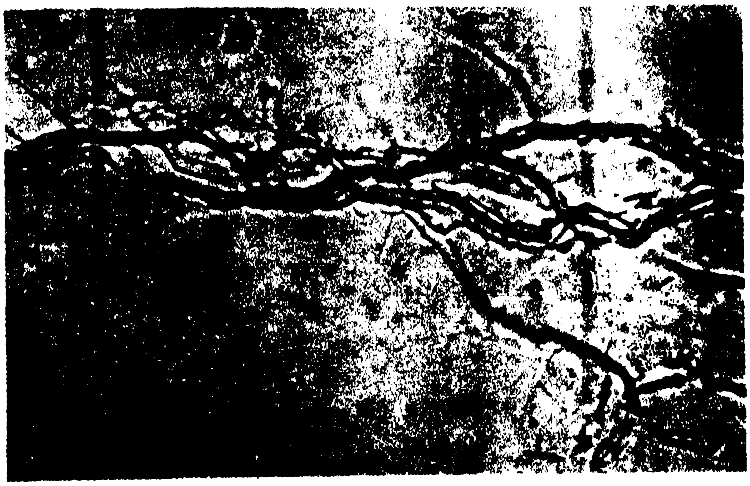


FIG. 2 DAMAGED JUTE FIBRE

where

a = the number of damaged fibres, and

b = the number of undamaged fibres.

6.2.2.6 Examine 5 to 10 slides (covering about 500 fibres in all) and calculate the average of all the values obtained.

6.2.2.7 Following the procedure prescribed in **6.2.2.1** to **6.2.2.6**, determine the average damage count of the fibres in the control specimen drawn as in **3.4.3** or **3.5.3**.

6.2.2.8 Compare the damage count values obtained as in **6.2.2.6** and **6.2.2.7**.

NOTE — The control specimen shall always show a lower damage count value than the test specimen. If the difference of the damage count of the control and test specimen's is more than 10, the fabric should be declared as damaged.

7 REPORT

The report shall include the following information :

a) Nature of damage in the yarn or cordage;

b) Whether fungi are present;

c) Whether bacteria are present;

d) Loss in breaking load, percent, of the basic yarn or cordage after being damaged;

e) Damage count of the test specimen; and

f) Damage count of the control specimen.

TESTING OF JUTE FABRICS FOR RESISTANCE TO ATTACK BY MICRO-ORGANISMS

(*Source* : IS 1623 : 1992)

Jute fabrics are liable to deterioration by the action of micro-organisms. Since they are often stored, transported and used under conditions favourable for the growth of micro-organism, various preservative treatments have been developed and their number is constantly increasing.

Two methods for testing jute fabrics for resistance to attack by micro-organisms have been prescribed in this standard, namely, mixed culture method and soil burial method. In the first method, a mixture of spores of five different fungi which are frequently the cause of deterioration of jute fabrics, is used.. In the second method, the fabric is subjected to the action of a much greater variety of micro-organisms, both fungi and bacteria, normally found in the soil.

The mixed culture method prescribed in this test method serves to assess the behaviour of jute fabrics under exposure to humid warm atmosphere whereas the soil burial method serves to assess their behaviour under conditions of contact or contamination with soil. Since, often a combination of the above two conditions exists in practice in relation to the use of the fabrics, both the methods are to be used.

This test method is based on the extensive research carried out by the Indian Jute Industries Research Association (IJIRA) Calcutta. Cultures of the organisms prescribed in this method for the tests can be obtained from IJIRA, 17 Taratola Road, Calcutta 700088. To facilitate supply, the culture members as set out below may also be mentioned.

Micro-organisms	IJIRA *Culture No.*
Chaetomium indicum	75
Curvularia lunata	10.1
Aspergillus fumigatus (*see* Note)	14
Penicillium rubrum	127.1
pencillium wortmanni	130.63

NOTE — *Aspergillus fumigatus* has been found to cause infection of lungs and of external ear in human beings. Great care should, therefore, be taken in handling the organisms not to inhale the spore dust from the culture tube when preparing the mixed spore suspension (*see* Annex B).

The methods prescribed here can also be used to evaluate preservatives or treatments designed to protect jute fabrics from damage by micro-organisms. In such cases, the preservative or the treatment has to be applied to a uniformly good quality jute fabric by the procedure recommended by the supplier or the originator and the treated fabric then tested.

1 SCOPE

It prescribes two methods, namely mixed culture method and the soil burial method for evaluating jute fabrics for resistance to attack by micro-organisms.

2 ATMOSPHERIC CONDITIONS FOR CONDITIONING AND TESTING

2.1 The tests shall be carried out under the conditions laid down in the respective test procedures. However, the specimens for breaking load testing shall be conditioned to moisture equilibrium and tested in the standard atmosphere at 65 ± 2 percent relative humidity and 27 ± 2°C temperature (*see* IS 6359 : 1971 'Method for conditioning of textiles' (Section B-1/1).

2.2 When the specimens have been left in such an atmosphere for 24 hours in such a way as to expose, as far as possible, all portions of the specimens to the standard atmosphere, they shall be deemed to have reached moisture equilibrium.

3 SAMPLING

3.1 Lot

The quantity of one definite type of jute fabric delivered to a buyer against one despatch note shall constitute a lot.

3.2 Samples shall be drawn so as to be representative of the lot. Samples drawn in accordance with the procedures laid down in material specifications or as agreed to between the buyer and the seller shall be taken as representative of the lot.

3.3 Take a sufficiently long piece (*see* Note under **3.7**) from each sample selected. Cut it into two pieces of unequal lengths, one of the pieces being nearly half the length of the other. Mark the smaller piece to identify it as the test piece; set aside the other piece for leaching (*see* **3.6**).

3.4 From the basic fabric, cut a piece of length equal to the length or the test piece and mark it to identify it as the control piece (*see* Note under **3.7**).

3.5 From the test pieces (*see* **3.3**), cut at random a set of 18 specimens, each of size 25 cm × 4 cm, with their longer sides parallel to warp threads. Mark the specimens so that they can be identified as test specimens constituting the best sample.

3.6 From the unmarked pieces (*see* **3.3**), cut at random test pieces of suitable length with their longer sides parallel to warp threads such that they can be accommodated in the leaching chamber (*see* Annex A). Leach the test pieces one by one according to the method prescribed in Annex A and dry them in air. Cut each of the leached pieces at random to obtain a set of 18 leached specimens, each of size 25 cm × 4 cm. Mark the specimens so that they can be identified as leached test specimens constituting the leached test sample.

3.7 From the control piece (*see* **3.4**), cut at random a set of 18 specimens, each of size 25 cm × 4 cm, with their longer sides parallel to warp threads. Mark the specimens so that they can be identified as control specimens constituting the control sample.

NOTE — The total length of the pieces will depend on the width of the fabric, but it should be such that one-third of the length is sufficient to give 18 specimens according to **3.5**. If an authentic sample of the basic fabric is not available, a fabric similar in construction to the one under test and free from size and finish should be used.

3.8 Ravel down to 14 threads all the specimens in the test sample (*see* **3.5**), leached test sample (*see* **3.6**) and control sample (*see* **3.7**), trimming off the weft threads.

4 MIXED CULTURE METHOD

4.1 Apparatus

4.1.1 *Small Petri Dishes*

Each 10 cm in diameter and provided with a lid.

4.1.2 *Large Petri Dishes*

Each 15 cm in diameter and 3 cm high, provided with a lid.

4.1.3 *Pipettes* of 1 ml capacity each.

4.2 Test Organisms

Cultures of the following test organisms:

a) *Chaetomium indicum,*
b) *Curvularia lunata,*
c) *Aspergillus fumigatus,*
d) *Penicillium rubrum, and*
e) *Penicillium wortmanni.*

4.3 Procedure

4.3.1 Draw at random 6 test specimens (*see* **3.8**). Condition them to moisture equilibrium in the standard atmosphere (*see* **2**) and determine the breaking load of each specimen by the method prescribed in IS 1969 : 1985 given in Section B–3/6. Find the average of all the values.

4.3.2 From the leached test sample (*see* **8**), draw at random 6 specimens. Condition them to moisture equilibrium in the standard atmosphere (*see* *2*) and determine the breaking load of each specimen by the method prescribed in IS 1969 : 1985 given in B-3/6. Find the average of all the valves.

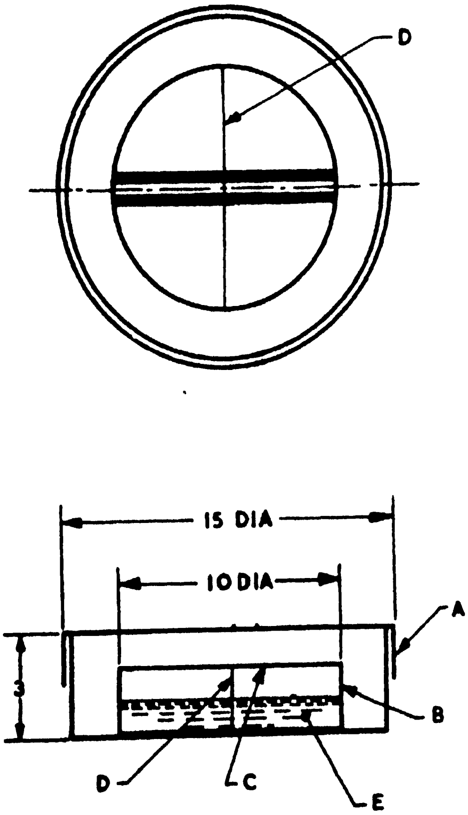
4.3.3 Draw at random m 6 control specimens (*see* **3.8**). Condition them to moisture equilibrium in the standard atmosphere (*see* **2**) and determine the breaking load of each specimen by the method prescribed in IS 1969 : 1985 given in Section B-3/6. Find the average of all the values.

4.3.4 Prepare in the manner prescribed in Annex B, (a) Czapek Dox salt agar medium, and (b) a mixed suspension of the spores of the test organisms prescribed in **4.2.**

4.3.5 Draw from the test sample (*see* **3.8**) six test specimens.

4.3.6 Melt sterilized Czapek Dox salt agar medium (20 ml) and pour in each sterilized small petri dish and allow the agar medium to set firmly. Leave the plates overnight to dry up the excess moisture on the surface of the agar medium. Remove the lid of the petri dish and place two sterilized specimens (as described in Annex D) on the agar plate side by side such that the central portion (about 4 cm) of each specimen touches lightly the agar surface and the two edges of each hang outside the petri dish. Inoculate the specimen by spreading 1.5 ml of the mixed spore suspension on the central portion of each specimen (*see* Fig. 1 and 2).

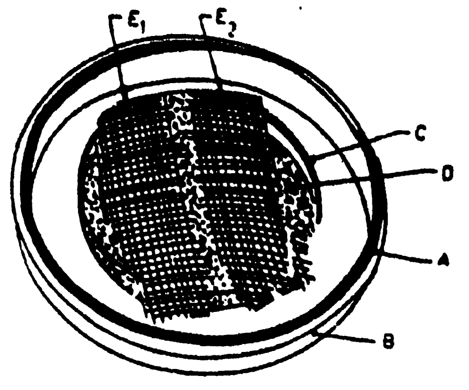
4.3.6.1 Fold carefully the free edges of the specimen down the outer lower side of the agar plate and carefully place the agar plate inside a sterilized large petri dish and cover it with a lid. Finally put all the petri dish assemblies in an incubator at 30 ± 2°C and 100 percent relative humidity. The control specimens are incubated for 10 days, whereas test specimens, leached and unleached are incubated for 21 days. After incubation is complete remove the specimens, wash them gently to free them from agar, and dry them in air (*see* Note). Condition each specimen to moisture equilibrium in the standard atmosphere and determine the breaking load of each specimen by the method prescribed in IS 1969 : 1985 given in Section B-3/6. Find the average of all the values.



A — Large petri dish
B — Small petri dish
C — Specimen
D — Supporting thread
E — Water

All dimensions in millimetres.

FIG. 1 PETRI DISH ASSEMBLY



A — Lid of the big petri dish
B — Big petri dish
C — Small petrid without lid
D — Mineral salt agar layer
E_1 and *E_2* — Jute fabric samples

FIG. 2 SCHEMATIC REPRESENTATION OF THE TESTING SYSTEM FOR EVALUATION OF THE RESISTANCE OF JUTE SAMPLES TO ATTACK BY FUNGI

NOTE — Exposure of test specimens after washing to methyl alcohol fumes in a desiccator for 2 to 4 hours before drying is desirable.

4.3.7 Draw 6 specimens from the leached test sample (*see* **3.8**) and test them in the manner prescribed in **4.3.6**.

4.3.8 Draw 6 control specimens from the control sample (*see* **3.8**) and test them in the manner prescribed in **4.3.6**. If the control specimens are not covered with profuse visible growth of micro-organisms, the test shall be repeated.

4.3.9 Calculate the loss in breaking load, percent of the basic fabric on incubation (*L*) by the following formula:

$$L = \frac{100(a-b)}{a}$$

where

a = average breaking load value obtained as in **4.3.3**, and

b = average breaking load value obtained as in **4.3.8**.

If the value of L is less than 70 percent, the test shall be repeated.

4.3.10 Calculate in the manner prescribed in **4.3.9** the loss in breaking load, percent, of the fabric under test on incubation prior to leaching, equating to:

'a' the value obtained as in **4.3.1**, and
'b' the value obtained as in **4.3.6**.

NOTE — The fabric should be considered satisfactorily resistant to attack by micro-organisms if the value of L does not exceed 20 percent.

4.3.11 Calculate in the manner prescribed in **4.3.9** the loss in breaking load, percent, of the fabric under test on incubation after leaching, equating to:

'a' the value obtained as in **4.3.2**, and
'b' the value obtained as in **4.3.7**.

NOTE — The fabric should be considered satisfactorily resistant to attack by micro-organisms if the value of L does not exceed 20 percent.

5 SOIL BURIAL METHOD

5.1 Apparatus

5.1.1 *Glass Jars*

Round, wide-mounted, flat-bottomed.

5.1.2 *Petri Dishes*

As covers.

5.1.3 *Incubator*

Capable of being maintained at 30 ± 2°C and provided with trays full of water at the bottom.

5.2 Test Soil

Prepared as prescribed in Annex C.

5.3 Procedure

5.3.1 Take the remaining 6 test specimens (*see* **3.8**).

5.3.2 Spread the test soil on each specimen in a thin layer and roll it lightly into the form of a cylinder. Place each specimen separately in a glass jar of suitable size containing a thin layer of soil at the bottom, and pour soil in the jar to cover the sides and top of the specimen, thus bringing both sides of the specimen in contract with the soil. The soil inside the jars should cover about three-fourth of their height and the specimens should be about 5 cm to 6 cm below the soil surface. Cover the jars with petri dishes and keep them in the incubator at 30 ± 2°C. Incubate the specimens for 21 days. After 21 days of incubation, check the moisture of the soil and, if need be, adjust the moisture to 25 to 27 percent. Remove the specimens, wash them gently to free them from soil, and dry them in air (*see* Note). Condition the specimens to moisture equilibrium in the standard atmosphere and determine the breaking load of each specimen by the method prescribed in IS 1969 : 1985 given in Section B-3/6. Find the average of all the values.

NOTE — Exposure of the test specimen after washing to methyl alcohol fumes in a desiccator for 2 to 4 hours before drying given better results.

5.3.3 Take the remaining 6 leached test specimens (*see* **3.8**) and test them in the manner prescribed in **5.3.2**.

5.3.4 Take the remaining 6 control test specimens (*see* **3.8**) and test them in the manner prescribed in **5.3.2**.

5.3.5 Calculate the loss in breaking load, percent, of the basic fabric on soil burial (L) by the following formula:

$$L = \frac{100\,(a-b)}{a}$$

where
a = average breaking load value obtained as in **4.3.3**, and
b = average breaking load value obtained as in **4.3.4**.

If the value of L is less than 80 percent, the test shall be repeated.

5.3.6 Calculate in the manner prescribed in **5.3.5** the loss in breaking load, percent, of the fabric under test on soil burial prior to leaching, equating to:

'a' the value obtained as in **4.3.1**, and
'b' the value obtained as in **5.3.2**.

NOTE — The fabric should be considered satisfactorily resistant to attack by micro-organisms if the value of L does not exceed 20 percent.

5.3.7 Calculate in the manner prescribed in **5.3.5** the loss in breaking load, percent, of the fabric under test on soil burial after leaching, equating to:

'a' the value obtained as in **4.3.2**, and
'b' the value obtained as in **5.3.3**.

NOTE — The fabric should be considered satisfactorily resistant to attack by micro-organisms if the value of L does not exceed 20 percent.

7 REPORT

The report shall include the following information:

Mixed Culture Method

a) Type of fabric under test;

b) Loss in breaking load, percent, of the basic fabric on incubation (*see* **4.3.9**);

c) Loss in breaking load, percent, of the fabric under test on incubation prior to leaching (*see* **4.3.10**); and

d) Loss in breaking load, percent, of the fabric under test on incubation after leaching (*see* **4.3.11**).

Soil Burial Method

a) Type of fabric under test;

b) Loss in breaking load, percent, of the basic fabric on soil burial (*see* **5.3.5**);

c) Loss in breaking load, percent, of the fabric under test on soil burial prior to leaching (*see* **5.3.6**);and

d) Loss in breaking load, percent, of the fabric under test on soil burial after leaching (*see* **5.3.7**).

ANNEX A

(*Clause* 3.6)

METHOD OF LEACHING

A-1 APPARATUS

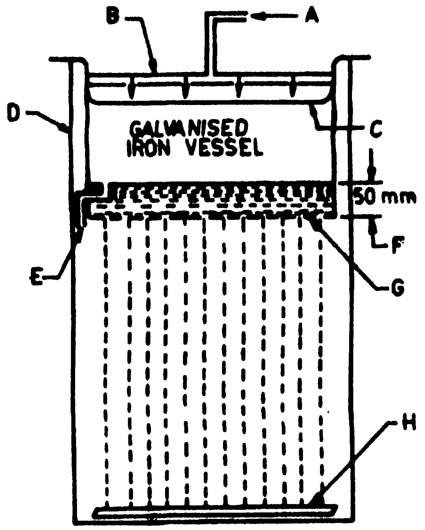
A-1.1 Leaching Apparatus (*see* Fig. 3)

Consisting of a rectangular galvanized iron vessel of convenient size (*see* Note), provided with a copper bottom with perforations 0.4 mm in diameter and 20 mm apart and an automatic device to maintain the level of water in it at a height of 50 mm the vessel being so fixed that its bottom is 300 mm above the horizontal glass base of the apparatus. Which is of the same size as the perforated bottom of the vessel.

NOTE — The size of the vessel should be such as to enable the whole leaching operation to be completed within a reasonable period of time, the fabric being cut into pieces of suitable size (multiples of test pieces) which should then be leached one by one.

A-2 PROCEDURE

A-2.1 Place a piece of the fabric under test on the horizontal glass base. Feed tap water (*p*H 6.5 to 7.5, at 30 ± 2°C) continuously for 4 hours into the vessel of the apparatus and let it fall in a shower on the specimen. Turn over the specimen after 2 hours and remove it at the end of 4 hours.



A — Water inlet
B — Supply tube with evenly distributed holes at the bottom
C — Baffle sheet
D — Wooden stand
E — Constant level outlet
F — Level of water
G — Performed bottom of vessel
H — Glass base (27×55cm) for holding the samples

FIG. 3 LEACHING APPARATUS

ANNEX B

(*Clause* 4.3.4)

PREPARATION OF CZAPEK DOX SALT AGAR MEDIUM AND MIXED SPORE SUSPENSION

B-1 PREPARATION OF CZAPEK DOX SALT AGAR MEDIUM

B-1.1 Dissolve the following salts in Quantities indicated per 100 ml of distilled water.

Solution A

Sodium nitrate ($NaNO_3$)	0.8 g
Magnesium sulphate ($MgSO_4.7H_2O$)	0.2 g
Potassium chloride (KCl)	0.2 g

Solution B

Potassium dihydrogen phosphate (KH_2PO_4)	0.1 g
Dipotassium hydrogen phosphate (K_2HPO_4)	0.3 g

During preparation of the medium, mix solution A and B in the proportion 1:1. Add equal volume of distilled water. Finally add agar (2 percent *m/v*). Heat on a water bath to dissolve agar and dispense in culture tubes in 20 ml quantities each. Plug the culture tubes with non-absorbent cotton and sterilize the medium in an autoclave at 103.35 kPa (15 psi) for 15 min.

B-2 PREPARATION OF MIX SPORE SUSPENSION

B-2.1 Media and Salt Solution

B-2.1.1 *Czapek Dox Agar Slants*

Prepare Czapek Dox-agar medium as described in **B-1**. Dispense 7 ml of this medium in culture tubes, plug and sterilize at 103.35 kpa (15 psi) for 15 min. In a separate culture tube, sterilize several filter paper strips (1 cm × 6 cm) in a similar way. Following sterilization, place the culture tubes containing hot, molten medium in a slanting position until the agar solidifies. Next introduce filter paper strips on the surface of agar slants aseptically, one filter paper per agar slant.

B-2.1.2 *Malt Extract-Peptone Agar Slants*

Dissolve 2.5 g of malt extract and 0.1 g of peptone in 100 ml distilled water. Adjust *p*H to 6.0. Add agar (2 percent *m/v*) and dissolve it by heating over a water bath. Dispense in culture tubes, 7 ml quantities per tube, plug with non-absorbent cotton and sterilize at 103.35 kPa (15 psi) for 15 min. Following this, prepare malt agar slants by keeping the culture tubes containing hot, molten malt agar in a slanting position, until the agar solidifies.

B-2.1.3 Quadruple strength Czapek Dox salt solution with 0.01 percent triton:

Dissolve the following salts in quantities indicated per 100 ml of distilled water.

Solution A

Sodium nitrate ($NaNO_3$)	1.6 g
Magnesium sulphate ($MgSO_4.7H_2O$)	0.4 g
Potassium chloride (KCl)	0.4 g

Solution B

Potassium dihydrogen phosphate (KH_2PO_4)	0.2 g
Dipotassium hydrogen phosphate (K_2HPO_4)	0.6 g

Sterilize each solution separately. After auto-claving at 103.35 kPa (15 psi) for 15 min, mix the two solutions when cold and add sterilized triton water so that the final concentration of triton in the solution becomes 0.01 percent (*v/v*).

B-2.2 Maintenance of Cultures

B-2.2.1 The following fungal strains shall be preserved in Czapek Dox filter paper agar slants:

a) *Chaetomium indicum*
b) *Curvularia lunata*
c) *Aspergillus fumigatus*
d) *Pencillium rubrum*

B-2.2.2 *Penicillium wortmanni*, however, shall be preserved malt extract peptone agar-slants.

B-2.3 Sub-cultures

B-2.3.1 Inoculate malt extract-peptone agar slants separately with well sporulated cultures of the above mentioned five organisms. Incubate the tubes at 30 ± 2°C for 7 to 10 days until mature growth of the organisms is obtained. Equal number of sub-cultures shall be made for each fungal culture.

B-2.4 Preparation of Mixed Spore Suspension

B-2.4.1 Take equal number of malt agar slant cultures of each of the 5 micro-organisms mentioned above. Add 5 ml quadruple strength Czapek Dox salt solution supplemented with 0.01 percent triton to each culture tube. Lightly scratch the surface of growth aseptically by a sterilized glass rod and rotate the culture tubes between the palms until the spore suspension in the tube is moderately dense. Filter the spore suspension through a piece of sterile muslin or suspension through a piece of sterile muslin or cotton-wool in a sterilized Erlenmeyer flask. In a similar way, pool spore suspensions from all the slant cultures in the same Erlenmeyer flask. Mix the spores well by placing the flask on a cyclomixer.

ANNEX C

(*Clause* 5.2)

PREPARATION OF TEST SOIL

C-1 Prepare a compost by mixing thoroughly fertile garden soil, cowdung manure and sand in the proportion of 2 : 1 : 1. Pass it through 355µm IS Sieve [*see* IS 460 (Part1) : 1978]. Adjust its moisture content to 25 to 27 percent and test it in the manner prescribed in **C-1.1** to **C-1.5**.

C-1.1 Take a sufficiently long piece of hessian of the following construction and draw from it 12 pieces, each of size 25 cm × 4 cm:

Ends/cm	4
Picks/cm	4
Mass, g/m^2	270

C-1.2 Take 6 pieces of the hessian, condition them to moisture equilibrium in the standard atmosphere (*see* **2**) and determine the breaking load of each by the method prescribed in IS 1969 : 1985 given in B-3/6. Find the average of all the values.

C-1.3 Test the remaining 6 pieces of the hessian in the manner prescribed in **5.3.2**, incubating the pieces for 7 days only. Record the average value for breaking load.

C-1.4 Calculate the loss in breaking load, percent, of the cloth after soil burial.

C-1.5 The soil shall be deemed to be suitable for the test if the loss in breaking load of the cloth, so determined is 80 percent or more.

ANNEX D

(*Clause* 4.3.6)

STERILIZATION OF JUTE SPECIMENS IN METHYL ALCOHOL VAPOUR

D-1 PROCEDURE

D-1.1 Pack the specimens loosely in a desiccator of suitable size containing methyl alcohol and keep them for 24 hours (or longer) at room temperature. In the meantime, make another desiccator ready by sterilizing it with methyl alcohol vapour for a period of 12 hours at room temperature. Transfer the specimens from the first desiccator to the second desiccator with a pair of sterile tongs in a sterile chamber/environment. Connect the second desiccator to a vacuum pump through a cotton-wool filter and exhaust the desiccator at room temperature for 6 hour to remove traces of methyl alcohol. Bring the pressure in the desiccator to the atmospheric pressure by slowly letting in air through the cotton-wool filter.

METHOD FOR TESTING FLAX FABRICS FOR RESISTANCE TO ATTACK BY MICRO-ORGANISMS

(*Source* : **IS 3856 : 1966**)

The flax fabrics are mainly used for making hoses used by fire services for pumping water for extinguishing fire outbreaks. Like cotton, flax is also liable to deterioration by the action of micro-organisms. Since fire hoses are often stored, transported and used under conditions favourable for growth of micro-organisms, protective treatments are applied.

Studies on the pattern of microbial degradation of flax fabrics in soil have revealed the predominant activity of the two fungi, namely, *Pencillium funiculosm* and *Memnoniella echinata*. These two fungi cause more than 90 percent loss in the breaking strength when used in 'pure culture' test in 42 days. Whilst in soil enriched with these fungi, flax fabrics register 100 percent loss in breaking strength in 28 days.

Two quantitative methods, namely, 'soil burial' method and 'mixed culture' method, have been prescribed in this test method. The soil burial method is intended for testing rotproofness of the treatment, involving burial in composted soil enriched with the two specific fungi; while the mixed culture method determines the resistance of the flax fabric to fungal attack by infecting the fabric with *Penicillium funiculosm* and *Memnoniella echinata*.

These methods may also be used for evaluating preservatives or treatments designed to protect flax fabrics from damage due to micro-organisms.

Cultures of the organisms prescribed in this standard for this test may be obtained from the Director, Defence Research Laboratory (Materials), P.B. No.320, kanpur, To facilitate supply, the culture numbers as referred below may also be mentioned:

Micro-organism	D.R.L. (M) Culture No.
Memnoniella echinata	843
Penicillium funiculosm	844

1 SCOPE

It prescribes methods for evaluating flax fabrics for resistance to attack by micro-organisms.

2 SAMPLING

2.1 Lot

The quantity of flax fabrics of the same type and quality delivered to a buyer against a despatch note shall constitute a lot.

2.2 Unless otherwise agreed to between the buyer and the seller the number of pieces to be selected at random from a lot shall be as given below:

Lot Size	*Sample Size*
Up to 150	3
151 to 300	4
301 to 500	5
501 and above	7

2.3 The pieces thus selected shall constitute the **test sample.**

2.4 From the basic fabric, take sufficiently long piece. The piece thus taken shall constitute the **control sample.**

3 SOIL BURIAL METHOD

3.1 Test Soil

For the purpose of this method, prepare test soil in the manner prescribed in Annex A.

3.2 Spore Suspension

3.2.1 Prepare the spore suspension of the following organisms in the manner prescribed in Annex B;

a) *Memnoniella echinata*, and

b) *Penicillium funiculosm*.

3.3 Procedure

3.3.1 From each piece in the test sample, cut out, at random, at least 3 test specimens so that the total number of test specimens obtained is at least 15. Each test specimen shall be 325 mm × 60 mm in size with the longer side parallel to warp threads. Mark these test specimens suitably for identification. The test specimens thus obtained shall be divided into 3 equal groups each containing at least one test specimen from each piece.

3.3.2 Take the test specimens belonging to the first group and determine the breaking load of each test specimen by the method prescribed in **9.1** of IS 1969 : 1968 'Method for determination of breaking load and elongation at break of woven fabric (by constant-rate-or-traverse machine)'. (*see* Section B-3/6). Find the average of all the test values.

NOTE — The size of the test strip should be 200 mm × 50 mm.

3.3.3 Put the test soil in different 1-litre glass jars (17 cm in height and 6 cm in diameter) having metallic screw caps. Spray 5 ml of the mixture of two spore suspensions on the test soil (*see* Note). Bury one test specimen belonging to the second group in each jar in such a way that the test specimen takes up 'U' shape inside the soil with two free ends (each 5 cm) projecting above the soil surface. Incubate the specimens at 30 ± 2°C and 98 ± 2 percent relative humidity for 28 days. At the end of this period, remove the specimen, wash free from soil, dry them in air and determine the breaking load of each specimen by the method prescribed in **9.1** of IS 1969 : 1968 'Method for determination of breaking load and elongation at break of woven fabric (by constant-rate-or traverse machine)' (*see* section B-3/6). Find the average of all the test values.

NOTE — While preparing soil compost the mixture of suspension is added to the soil and moistened adequately to have specified moisture content.

3.3.4 Leach the test specimens belonging to the third group in the manner prescribed in Annex C and test them in the manner prescribed in **3.3.3**.

3.3.5 From the control sample cut at random 10 test specimens each measuring 325 mm x 60 mm with their longer sides parallel to warp threads. Take five specimens and determine the breaking load of each individual specimen by the method prescribed in **9.1** of IS 1969 : 1968 'Method for determination of breaking load and elongation at break of woven fabric (by constant-rate-or-traverse machine)' (*see* Section B-3/6). Find the average of all the test values.

3.3.6 Test the remaining five specimens in the manner prescribed in **3.3.3**.

3.3.7 Calculate the loss in breaking load, percent, of the basic fabric, on soil burial, by the following formula:

$$L = \frac{100\,(a-b)}{a}$$

where

L = Loss in breaking load, percent, of the basic fabric on soil burial,

a = Average breaking load value obtained as in **3.3.5**, and

b = Average breaking load value obtained as in **3.3.6**.

NOTE — The value of L should be 90 percent or more. If this value is less than 90 percent, the test should be repeated.

3.3.8 Calculate in the manner prescribed in **3.3.7**, the loss in breaking load, percent, of the fabric under test on *soil burial without prior leaching* but equating to:

'a' value obtained as in **3.3.2**, and
'b' value obtained as in **3.3.3**.

NOTE — The value of L should not be more than 10 percent. The fabric should be considered satisfactorily resistant to attack by micro-organisms if the value of L does not exceed 10 percent.

3.3.9 Calculate in the manner prescribed in **3.3.7** the loss in breaking load, percent, of the fabric under test on *soil burial after leaching* but equating to:

'a' value obtained as in **3.3.2**, and
'b' value obtained as in **3.3.4**.

NOTE — The value of L should not be more than 10 percent. The fabric should be considered satisfactorily resistant to attack by micro-organisms if the value of L does not exceed 10 percent.

3.4 Report the results of the test as under:

a) Loss in breaking load, percent of the basic fabric on soil burial (*see* **3.3.7**);

b) Loss in breaking load, percent of the fabric under test on soil burial without prior leaching (*see* **3.3.8**); and

c) Loss in breaking load, percent of the fabric under test on soil burial after leaching (*see* **3.3.9**).

4 MIXED CULTURE METHOD

4.1 Apparatus

For the purpose of this test, petri dishes each 15 cm in diameter and 4 cm in height shall be used.

4.2 Test Organisms

For the purpose of this test, cultures of the following organisms shall be used:

a) *Memnoniella echinata*, and
b) *Penicillium funiculosm.*

4.3 Test Medium – Prepared by mixing the following:

Ammonium nitrate	3.0 g
Potassium dihydrogen phosphate	0.25 g
Magnesium sulphate	0.25 g
Potassium chloride	0.25 g
Agar-agar	25 g

in one litre of distilled water [*see* IS 1070 : 1993 'Reagent grade water (*third revision*)'] and sterilizing with steam at a pressure of 1.1 kg per square centimetre for 20 minutes.

NOTES

1 Only 'pure chemicals' shall be used for preparing medium. 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the results of the test.

2 The *p*H of the medium should be 6.4.

4.4 Procedure

4.4.1 From each piece in the test sample, cut out at random at least 2 test specimens so that the total number of test specimens obtained is at least 10. Each test specimen shall be 325 mm × 60 mm in size with the longer side parallel to the warp threads. Mark these test specimens suitably for identification. The test specimens thus obtained shall be divided into 2 equal groups each containing at least on test specimen from each piece.

4.4.2 Prepare in the manner prescribed in Annex B a mixed suspension of spores of the test organisms prescribed in **4.2**.

4.4.3 Take the test specimens belonging to the first group. Sterilize the specimens in the manner prescribed in Annex D and with sterile instruments transfer them to different sterile petri dishes each containing 60 to 70 ml of test medium. Roll up the two ends of the test specimens so that about 10 cm of the central portion is left exposed. Keep one test specimen in each dish. Inoculate the exposed portion of each specimen in steriled condition with 3 to 4 ml of the mixed spores suspension (*see* **4.4.2**). Incubate the specimens for 28 days at 30 ± 2°C and 90 ± 2 percent relative humidity. At the end of the period, remove the specimens and record the degree of fungal growth as per the rating given in Table 1. Wash the test specimens with cold water till they are free from agar and determined the breaking load of each by the method prescribed in **9.1** of IS 1969 : 1968 'Method for determination of breaking load and elongation at break of woven fabric (by constant-rate-or-traverse machine)' (*see* Section B-3/6). Find the average of all the values.

4.4.4 Leach the test specimens belonging to the second group in the manner prescribed in Annex C and test them in the manner prescribed in **4.4.3**.

4.4.5 From the control sample, cut at random five control specimens and test them in the manner prescribed in **4.4.3**.

4.4.6 Calculate the loss in breaking load, percent of the basic fabric on inoculation by the following formula:

$$L = \frac{100\,(a-b)}{a}$$

where

L = Loss in breaking load, percent of the basic fabric on inoculation;
a = Breaking load, value obtained as in **3.3.5**; and
b = breaking load value obtained as in **4.4.5**.

NOTE — The value of L should be 60 percent or more. If this value is less than 60 percent, the test should be repeated.

Table 1 Degree of Fungal Growth

(*Clause* 4.4.3)

Symbolic Rating	State of Growth of Micro-Organisms	Rating in Terms of Resistance
(1)	(2)	(3)
-	No growth	Good
±	Very slight growth (visible only under magnifying glass)	Very fair
+	Slight growth (area of growth less than one-fourth of total)	Fair
++	Moderate growth (area of growth more than one-fourth but less than half)	Poor
+++	Heavy growth (area of growth more than half)	Very poor

4.4.7 Calculate in the manner prescribed in **4.4.6** the loss in breaking load, percent, of the fabric under test, *on inoculation without prior leaching* but equating to:

'*a*' the value obtained as in **3.3.2**; and
'*b*' the value obtained as in **4.4.3**.

NOTE — The value of *L* should not be more than 10 percent. The fabric should be considered satisfactorily resistant to attack by micro-organisms if the value of *L* does not exceed 10 percent.

4.4.8 Calculate in the manner prescribed in **4.4.6** the loss in breaking load, percent, of the fabric under test, *on inoculation after leaching* but equating to:

'*a*', the value obtained as in **3.3.2**; and
'*b*', the value obtained as in **4.4.4**.

NOTE — The value of *L* should not be more than 10 percent. The fabric should be considered satisfactorily resistant to attack by micro-organisms if the value of *L* does not exceed 10 percent.

4.5 Report the results of the test as under:

a) Loss in breaking load, percent, of the basic fabric on inoculation (*see* **4.4.6**),

b) Loss in breaking load, percent, of the fabric under test on inoculation without prior leaching (*see* **4.4.7**), and

c) Loss in breaking load, percent of the fabric under test on inoculation after leaching (*see* **4.4.8**).

ANNEX A

(*Clause* 3.1)

PREPARATION OF TEST SOIL

A-1 PROCEDURE

A-1.1 Mix thoroughly:

a) a layer of good, sandy loam soil, 13 cm thick;
b) a layer of fresh cow-dung manure 7.5 cm thick; and
c) a layer of finely chopped straw 15 cm thick.

Allow the mixture to ferment for 2 months turning it once a weak, maintaining the moisture content at 22 to 25 percent on the total weight of the mixture. At the end of the period, sift the resulting compost through 3.35-mm IS Sieve (*see* IS 460 : 1962 'Specification for test sieves') and test it in the manner prescribed below.

A-1.1.1 Take a light-weight cotton fabric weighing 240 to 255 g per square metre. Draw six 325 mm × 60 mm pieces from it. Take three pieces and determine the breaking load of each individual piece by the method prescribed in **9.1** of IS 1969 : 1961given in Section B-3/6. Find the average of all the values.

A-1.1.2 Bury the remaining three pieces in the compost (*see* **A-1.1**) for 5 days. At the end of the period, remove the pieces from the compost and determine the breaking load of each individual piece by the method prescribed in **9.1** of IS 1969 : 1961 given in Section B-3/6. Find the average of all the values.

A-1.2 Calculate the loss in strength of the fabric after soil burial.

NOTE — The soil should be deemed to be suitable for test if the loss in strength of fabric so determined is 80 percent or more.

ANNEX B

(*Clauses* 3.2.1 *and* 4.4.2)

PREPARATION OF SPORE SUSPENSION

B-0 GENERAL

B-0.1 If a mixed suspension of spores of more than one test organism is to be prepared, the suspensions of spores of each test organism shall be prepared separately and the suspensions then mixed in equal volumes.

B-1 PREPARATION OF CULTURE MEDIUM

B-1.1 Take sufficient quantity of potatoes, say, about 250 g, peel them off and cut them into slices. Weigh 200 g of the sliced potatoes, wash them in running tap water and place them in a beaker; add 500 ml of distilled water and keep the contents at boil for 30 minutes. Filter the hot extract through a thin layer of absorbent cotton previously wetted with distilled water. Preserve the filtrate.

B-1.2 Take 25 g of agar, cut it into small pieces and boil, in the minimum quantity of distilled water necessary till no solid agar is visible. Add 20 g of dextrose and mix it with the filtrate (*see* **B-1.1**). Make up the volume to 1 000 ml with hot distilled water. Adjust the *p*H of the culture medium to 6.4.

NOTE — To avoid solidification, the temperature of the culture medium should be kept above 45°C.

B-1.3 Put 5 ml of the culture medium into each of a number of 15 cm × 2 cm test-tubes and plug them with non-absorbent cotton-wool. In an autoclave, sterilize the culture medium with steam at a pressure of 1.1 kg/cm^2 for 20 minutes. At the end of the period, remove the test-tubes from the autoclave, place them in a slanting position and allow them to cool to harden the culture medium into 'slants'.

B-2 PREPARATION OF SUB-CULTURE

B-2.1 Inoculate the slants in the test-tubes with a well-sporulated culture of test organism (*see* **3.2.1**) by means of a sterile needle. Incubate the slants for 7 days at 30 ± 2°C.

NOTE — At the end of this period, a heavy growth of the freshly sporulating test organism should be visible within the tubes.

B-3 PREPARATION OF SPORE SUSPENSION

B-3.1 Add about 10 ml of sterile distilled water to freshly sporulating subculture of the test organism (*see* **B-2**) within the tubes. Bring the spores of the sub-culture into suspension by shaking or disturbing them gently with a sterile glass rod. Filter the suspension through a sterile muslin or similar fabric to remove particles of agar or fungal mycelium. Examine a drop of the spore suspension under a low power microscope, and see whether 50 or more spores appear in the field.

ANNEX C

(*Clauses* 3.3.4 *and* 4.4.4)

METHOD OF LEACHING

C-1 PROCEDURE

C-1.1 Place the specimen inside a glass jar with internal diameter of 9 cm. Through a capillary, extending to within 0.6 cm of the bottom of the jar, allow water (with *p*H of not less than 6.0 and not more than 8.0 and temperature of 30 ± 2°C) to flow into it at the rate of 10 litres per hour. In this stream of water, leach the specimen for 24 hours.

ANNEX D

(*Clause* 4.4.3)

STERILIZATION IN METHYL ALCOHOL VAPOUR

D-1 PROCEDURE

D-1.1 Pack the specimens loosely in a desiccator of suitable size containing methyl alcohol and keep them for 24 hours (or longer) at room temperature (about 27°C). In the meantime, make another desiccator ready by sterilizing it with methyl alcohol vapour for a period of 12 hours at room temperature. Transfer the specimens from the first desiccator to the second desiccator with a pair of sterile tongs. Connect the second desiccator with a water pump through a cotton-wool filter and exhaust the desiccator at room temperature for 6 hours to remove traces of methyl alcohol. Bring the pressure in the desiccator to the atmospheric pressure by slowly letting in air through the cotton-wool filter.

METHOD OF TEST FOR EVALUATION OF INSECTPROOFNESS OF WOOLLEN TEXTILES

(*Source* : IS 7250 : 1995)

Woollen fabrics and garments are frequently damaged by larvae of dermested beetle and moths and result in enormous economic loss. Among beetles, the woolly bear (*Anthrenus flavipes Lec*) and the carpet beetle (*Attagenus fasciatus*); and among moths (*Tinea pellionella Linn and Tinea translucens*) and the webbing clothes moth (*Tineola bissellieIla Hum*) are mainly responsible for damage throughout India.

1 SCOPE

It prescribes a method for determination of the resistance of woollen textiles to the larvae of: (a) *Anthrenus flavipes*, (b) *Attagenus fasciatus*, and (c) *Tinea translucens*. It is applicable to all textiles containing wool fibres in any proportion.

2 PRINCIPLE

Conditioned voracity control specimens and test specimens of known mass are placed in contact with selected larvae for 14 days. The loss in mass of all specimens, the extent of the attack on test specimens and the condition of test larvae are ascertained to assess the resistance of each test specimen.

3 APPARATUS

3.1 Metal, glass or plastic containers of 45 mm diameter and 10 mm height with metal/plastic cover having 4 or 5 minute ventilating holes. This container shall be large enough to permit test larvae to remain in contact with, or move away from the test specimen.

3.2 Pointed forcep and a camel hair brush with pesticide free bristles.

3.3 Weighing bottles with stopper.

3.4 Balance capable of determining mass to an accuracy of 0.1 mg.

3.5 Die of 40 ± 1.5 mm diameter for punching circular test specimen.

4 CONDITIONING, REARING AND TESTING ATMOSPHERE

The atmospheric conditions for rearing and testing shall have 27 ± 1°C temperature and 65 ± 2 percent relative humidity.

5 SPECIMENS

5.1 Test Specimens

Eight test specimens shall be selected at random from the sample of material to be tested. Use four of these as test specimens and remaining four as moisture regain controls.

5.2 Voracity Control Specimens

As it is essential to provide a control on larval voracity, eight test specimens shall be selected from undyed unproofed woollen material or yarn corresponding to the sample to be tested. Use four of these eight specimens as larvae voracity control specimen and four as moisture regain controls.

5.3 Form and Characteristics

The specimen shall be of the form and size as given in Table 1.

Table 1 Form and Size of Specimens

Material	Form and Size
Woven or Knitted fabrics, felts and furs	Discs, 40 ± 1.5mm in diameter
Carpet	Squares approximately 30 mm × 30 mm with tuft and/or loops along the edges intact
Carpet pile alone	200 mg specimens
Yarn	200 mg specimens, wound into a loose hank in the container

6 TEST INSECTS

6.1 The larva of any of the following test insects shall be used. Choice of test species depends upon the species against which proofness is required. *Anthrenus flavipes* and *Attagenus fasciatus* are difficult to control and thus require high level of insectproofing agent than *Tinea translucens*:

a) *Anthrenus flavipes*	10-11 weeks old
b) *Attagenus fasciatus*	11-12 weeks old
c) *Tinea translucens*	24-27 days old

6.2 Details of breeding of the above larvae are given in Annex A. In case, there is any deviation in rearing medium or temperature and relative humidity, it may call for some deviation in the age of the larvae used for tests. In that case the deviation shall be indicated in the test report. Differences caused by variation in temperature and humidity are largely overcome by use of standard conditions given in **4**.

7 PROCEDURE

7.1 Condition all the sixteen specimens in the atmosphere specified in **4** for 24 hours. Then determine the mass of each specimen separately in a stoppered weighing bottle to an accuracy of 0.1 mg.

7.2 Place each of the test and voracity control specimens of known mass in a separate container. On to each of the four test specimens and the four voracity control specimens place fifteen larvae of the selected insect or pest (These larvae should be subjected to fasting for 24 h before their release on specimens).

7.3 Keep the sixteen containers in the dark in the test atmosphere for a period of 14 days.

7.4 After test period, remove all larvae, cast skins (exuviae) excrements and loose fibres from the test specimens and voracity control specimens by means of pointed forceps and a camel hair brush.

7.5 Count and record for each test specimen the number of surviving, dead or pupating larvae.

7.6 Transfer the test specimen, the voracity control specimens and moisture regain control specimens to small tared weighing bottles. Determine the mass separately of the test, voracity control and moisture regain control specimens.

7.7 Test is invalid if the mean loss in mass of the four voracity controls is less than 35 mg, or any single value is less than 25 mg or more than 25 percent of the control larvae die or pupate.

8 OBSERVATIONS AND CALCULATIONS

8.1 Method of Calculation and Formula

8.1.1 Determine the loss in mass (m) of each test specimen and voracity control specimen due to insect feeding as follows :

$$m = \frac{m_0 \times m_3}{m_2} - m_1$$

where

m_0 = mass of the test specimen or voracity control specimen before exposure to larvae,

m_1 = mass of the test specimen or voracity control specimen after exposure to larvae for 14 days,

m_2 = mean initial mass of appropriate moisture regain controls, and

m_3 = mean final mass of appropriate moisture regain controls.

8.2 Visual Assessment of Insectproofness

8.2.1 Examine each test specimen and assess the visible damage using the symbols given in Tables 2 and 3.

Table 2 Estimation of Cropping

Symbol	Cropping: Visible Surface Damage
1	No detectable damage
2	Very slight cropping
3	Moderate cropping
4	Very heavy cropping

Table 3 Estimation of Holes

Symbol	Estimation of Holes
A	No detectable damage
B	Yarn or fibres partially severed
C	A few small holes, yarn or fibres severed
D	Several large holes

8.3 Visual Assessment of Larval Condition

Count and record for each test specimen the number of larvae in each of the following conditions:

a) Live,
b) Dead, and
c) Pupating.

8.4 Assessment of Insectproofness

8.4.1 A tested sample of fabric, carpet or yarn shall be considered a borderline case of satisfactory insectproofness if any of the following applies:

a) Visible surface damage and estimation of holes is assessed as attack level 2 B on two of the test specimens and the remaining test specimens are undamaged.

b) Visible surface damage and estimation of holes is assessed as attack level 3 B on any one test specimen with the yarn or fibres partially severed at more than one point (indicative of uneven application) with the remaining test specimens are undamaged.

c) No surface damage is visible to the naked eyes but the mean loss in mass is greater than 15.0 mg or the loss in mass of any one test specimen is not greater than 20 mg.

8.4.2 A tested sample of fabric, carpet or yarn shall be considered satisfactorily proofed if the attack level is assessed as less than that defined as borderline under **8.4.1**.

8.4.3 If a tested sample of fabric, carpet or yarn has level greater than that defined as borderline under **8.4.1** then it shall be considered inadequately proofed. If estimation of holes is assessed as *C* or *D* on any test specimen, the sample also falls in this category.

9 TEST REPORT

The test report shall include the following:

a) Type of textile material under test;

b) Test insect species used;

c) Larval conditions at the end of the test;

d) Mean loss in mass, in mg, of the four test specimens;

e) Assessment of visible damage;

f) Mean loss in mass, in mg, of the four voracity control specimens;

g) Any deviation from the specified procedure; and

h) Assessment of insectproofness: Proof/ Borderline/Not Proof.

ANNEX A

(*Clause* 6.2)

BREEDING OF LARVAE OF TEST SPECIES

A-1 PRINCIPLE

The insect pests are cultured on suitable media for specified times under controlled atmospheric conditions. The cultures are sieved and the larvae of specified size and age are collected for use in the test.

A-2 INSECTS

The method describes procedures for rearing and maintaining the following insect pests:

a) *Anthrenus flavipes* (Le Conte) (beetle).
b) *Attagenus fasciatus* (Thunberg) (beetle).
c) *Tinea translucens* (Meyrick) (Moth).

A-3 APPARATUS

A-3.1 Rearing Containers – Glass jar of suitable shape and volume provided with fine mesh metal screen or cloth covers.

A-3.2 Test Sieves – of 0.8 mm, 1.00 mm and 1.25 mm aperture.

A-3.3 Pigeon Feathers (for handling larvae, etc) – rubber bands of various sizes.

A-3.4 Oviposition Jar (15 cm × 9 cm diameter) – covered with round mosquito net piece.

A-3.5 Aspirator – for removal of cast skins of larvae.

A-3.6 Petri Dishes – with glass cover.

A-4 MAINTENANCE OF CULTURES

A-4.1 *Anthrenus Flavipes* (Woolly Bear of Furniture Carpet Beetle)

a) *Medium*
All wool, undyed, scoured, worsted white serge or barrack blanket piece is treated with a solution containing 10 percent glucose, 1 percent brewer's yeast and 10 percent dry albumen. Dry albumen can be obtained from fresh hen's egg.

b) For starting a culture, about 100 adults are liberated on fabric pieces treated with medium in a container for a week. Adults after a week are removed from the container and liberated into a second such container for a week. This process is repeated at weekly interval. Add fresh medium as and when required. Remove excreta and cast skins of larvae when needed. After 11 or 12 weeks remove excess fabric and sieve the culture. Larvae that are retained by 1.00 mm sieve will be used for the test (This will produce larvae of 0.8 to 1.0 mg).

c) Selected larvae shall be kept in filter paper lined petri dish for fasting for 24 h before their release on the specimens.

A-4.2 *Attagenus Fasciatus* (the Banded Carpet Beetle)

a) *Media*

Medium 1

Fishmeal	70 g
Cornmeal	25 g
Powdered brewer's yeast	5 g

This formulation shall be ground to pass through a 0.8 mm sieve.

Medium 2

Dog's biscuit	95 g
Powdered brewer's yeast	5 g

b) For starting culture release some adults on the medium No. 1 or 2 in suitable container and fill three-fourths of it with medium. On the top of medium place a small piece of wool fabrics for shelter of adults. Sieve the culture in medium at interval of 11 to 12 weeks. Larvae that pass through 1.25 mm sieve but are retained by 1.00 mm sieve will be used for the test (This should produce larvae of 6 to 7 mg).

Add fresh medium as and when required. Remove dead larvae and cast skins at biweekly interval.

c) After 12th week sieve the culture and release the larvae on fresh medium.

A-4.3 *Tinea Translucens* (the Tropical Case Making Clothesmoth)

a) *Medium*

All wool undyed, scoured worsted white serge or barrack blanket piece, impregnated with a five percent dispersion of brewer's yeast in distilled water.

b) For starting a culture, freshly emerged adults are caught by aspirator and introduced daily in a glass oviposition container having pieces of filter paper for harbourage of moths. These jars are covered with round mesh mosquito netting held in place with a rubber band. Every morning, eggs are removed by inverting the oviposition jar in a glass dish. Cultures with known number of eggs (150 to 200) are started in a rearing container having above medium. Eggs hatch out within 5 to 6 days. Each culture thus contains about 150 to 200 larvae which will be used as test insects when 24 to 27 days old. Add fresh medium as and when required to the rearing jars. Remove excreta at 15 days interval.

c) Selected larvae shall be released in a petri dish for 24 h for fasting before their release on test and voracity specimens.

DETERMINATION OF DESIZING EFFICIENCY AND THE RELATIVE EFFICIENCY OF AMYLOLYTIC ENZYMES

(*Source* : **IS 647 : 1965**)

Desizing by 'rot steeping' has now become obsolete mainly because it takes long time and there are difficulties in controlling the fermentation reaction. Cloth desized by steeping in mineral acids, such as sulphuric acid or hydrochloric acid has low residual mineral contents. However, the process suffers from a serious risk of cellulose degradation during the action of acids if not properly controlled. As against these two methods, desizing with enzymes is very effective and economical. It can be easily controlled. Due to the specific nature of the action of enzymes, cellulose is not liable to attack at any stage

Amylolytic enzymes are water soluble colloidal organic catalysts which hydrolyze starch into water soluble products. Amongst them, three types, namely, malt extracts, pancreatic diastases and bacterial diastases are of use to the textile industry. However, chemically there are only two different forms of these enzymes, α-amylase and β-amylase, which split the starch in different ways. Both bacterial and certain pancreatic enzymes contain only α-amylase, whereas those of malt origin contain α and β in proportions which vary from sample to sample. It has been reported that malt amylases contain β-amylase to the extent of two to five times more than α-amylase.

The α-and β-amylases are readily distinguished by their initial mode of action. α-amylases are dextrinishing enzymes, rapidly splitting the starch molecules into low molecular weight dextrin, the reaction being physically manifested by rapid liquefaction. β-amylases on the other hand are saccharifying enzymes and their action results in formation of large molecules of sugars without any considerable liquefaction of starch. When the starch is not sufficiently liquefied, it will not be effectively removed in subsequent washing. Thus β-amylase along has no practical value in desizing.

The characteristics that distinguish the three different types of enzymes mentioned in **0.4** above are variations in their reaction conditions as time, temperature and *p*H. Enzymes of the same general type also differ from one another. The optimum *p*H and temperature of each of the three types of enzymes are as under:

	*Optimum p*H	*Optimum Temperature*
Malt preparations	4.5 to 5.5	55 to 65°C
Pancreatic preparations	7 to 8	45 to 55°C
Bacterial preparations	6.0 to 7.5	65 to 85°C

These enzymes are largely used in the cotton textile industry for desizing. If the starch is not removed from the fabric, it would interfere with the efficiency of kiering operation and also produce degradation products of a reducing nature which would act detrimentally on coloured yarn under treatment.

Two methods of evaluating desizing efficiency of enzymes have been prescribed.

The first method is suitable for determining the desizing efficiency as well as the relative efficiency of different enzymes. It is simple in operation and quick in evaluation. This is mostly suitable for evaluation of different enzymes for their desizing efficiency under the practical working conditions in desizing of fabrics which are normally adopted in textile industry. But it suffers from the defect that it is an indirect method and the test results have to be corrected for the hydrolyzed starch removed by rot steeping and the unhydrolysed starch removed mechanically along with hydrolysed starch by the squeezing roller through which the cloth is passed.

The second method determines only the relative efficiency of different enzymes. Further, it helps to give optimum working conditions of a particular enzyme to get the required results. In this method, the quantity of enzyme required to give definite flow time is determined.

1 SCOPE

It prescribes two methods for evaluating the desizing efficiency and the relative efficiency of amylolytic enzymes. In the first method conditions stipulated are similar to actual working conditions in mills. In the second method the amount of enzyme required to give a definite flow time is determined.

2 TERMINOLOGY

2.0 For the purpose of this test method, the following definitions shall apply.

2.1 Desizing Efficiency

The desizing efficiency of an amylolytic enzyme is a measure of its effectiveness to hydrolyze starch into products which are water soluble and as such mechanically removable from cloth. It is expressed in terms of percentage loss of starch (that is, starch hydrolyzed) from a fabric calculated on the total weight of starch in the fabric.

2.2 Relative Efficiency

The relative efficiency of enzyme is its desizing efficiency as compared with that of other enzymes. It is expressed in qualitative terms, such as 'more' and 'less' or 'higher' and 'lower'.

3 QUALITY OF REAGENTS

Unless otherwise specified, pure chemicals shall be employed in the tests and distilled water [*see* IS 1070 : 1993 'Reagent grade water (*third revision*)] shall be used where the use of water or distilled water as a reagent is intended.

NOTE — 'Pure chemicals' shall mean chemicals that do not contain impurities which affect the experimental results

4 FIRST METHOD

4.1 Procedure

4.1.1 Take about 5 g or more of good quality bleached long cloth free from residual sizing and finishing materials. Remove five threads from each side of the piece in order to avoid any loss of warp or weft threads in the subsequent processes. Dry the piece in a stoppered weighing bottle at 100 to 105°C to constant weight and weigh it accurately. Starch the piece by passage through a 10 ± 1 percent (*w/v*) mucilage of good quality maize starch previously adjusted to *p*H between 6.5 and 7.5. Squeeze the starched pieces through a pair of squeezing rollers set to about 100 percent squeeze. Dry the pieces first in hot air and then in the weighing bottle at 100 to 105°C to constant weight and weigh it accurately.

4.1.2 Similarly treat three more pieces for the test.

4.1.3 Calculate on oven-dry basis the starch present on each piece by the following formula:

$$d = W_2 - W_1$$

where

d = amount of starch in g, present on the piece;
W_2 = Weight, in g, on oven-dry basis, of the starched piece; and
W_1 = weight, in g, on oven-dry basis, of the unstarched piece.

4.1.4 Dissolve 1 g of enzyme under test in sufficient amount of water and make the volume to 1 litre.

4.1.5 Dissolve 1 g of sodium chloride in sufficient amount of water and make the volume to 1 litre.

4.1.6 Take two beakers and add 80 ml of water in each. Add to each beaker required amounts of enzyme solution (*see* **4.1.4**) and sodium chloride solution (*see* **4.1.5**) so that the amount of enzyme and sodium chloride taken for the test shall be 0.02 percent of the amount of starch present on the piece under test. Add the necessary amount of water to make the material-to-liquor ratio of 1: 20. Treat two starched pieces (*see* **4.1.1**) separately for five minutes one at 50°C and another at 70°C with enzyme solutions. Pass the two pieces separately through the squeezing rollers without changing their settings and leave them in separate stopper bottles at 38 ± 2°C for 18 to 20 hours. Wash each of the two pieces 6 times giving two dips each time in 400 ml of fresh water at room temperature, passing the piece after every wash through the squeezing rollers set as previously. Dry the two pieces at 100 to 105°C to constant weight and weight them accurately.

4.1.7 Calculate, one oven-dry basis, the percentage loss in weight of the pieces treated as in **4.1.6** by the formula given below:

$$a = \frac{W_2 - W_3}{d} \times 100$$

where

a = loss in weight, percent, of starch;
W_2 = oven-dry weight, in g, of the undesized starched piece;
W_3 = oven-dry weight, in g, of the desized starched piece; and
d = amount of starch present on the piece (*see* **4.1.3**).

4.1.8 Similarly treat the other two pieces by substituting water in place of the diluted enzyme solution.

NOTE — The material-to-liquor ratio should be 1 : 20.

4.1.9 Calculate on oven-dry basis, the percentage loss in weight of the pieces treated as in **4.1.8** by the following formula:

$$b = \frac{W_2 - W_4}{d} \times 100$$

where

b = loss in weight, percent, of starch;
W_2 = Oven-dry weight, in g, of the untreated starched piece;
W_4 = Oven-dry weight, in g, of the treated starched piece; and
d = amount of starch present on the piece (*see* **4.1.3**).

4.1.10 Calculate the desizing efficiency at 50°C and 70°C separately by the formula given below:

$$E = a - b$$

where

E = desizing efficiency of the enzyme;
a = loss in weight, percent, due to enzymic action (*see* **4.1.7**); and
b = loss in weight, percent, due to blank (*see* **4.1.9**).

4.2 Repeat the test by substituting 0.05 and 0.1 percent of enzyme or a lower concentration of enzyme as required in place of 0.02 percent of enzyme.

NOTE — The amount of sodium chloride taken for the test should be equal to the amount of the enzyme taken for the test.

4.3 Repeat the test as given in **4.1.1** to **4.2** for the remaining enzymes under test.

NOTE — It is not necessary to repeat the blank for tests carried out on the same day for the same setting of squeezing rollers

4.4 Compare the results (*see* **4.1.10**, **4.2** and **4.3**) to determine the relative efficiency of the enzymes under test bearing in mind that higher the desizing efficiency, more efficient is the corresponding enzyme.

5 SECOND METHOD

5.1 Apparatus

5.1.1 *Fluidity Tube*

With a short length of rubber tubing attached to the wider end of the tube (*see* Fig. 1) which is fitted vertically on a stand with a spring clamp.

5.1.2 *Stop-Watch*

To read correct to one-tenth of a second.

5.1.3 *Water-Bath*

5.2 Procedure

5.2.1 To about 800 ml of vigorously boiling distilled water, add in a thin stream of a dispersion of 40 g of maize starch made in 150 ml of cold distilled water. Stir well, boil for 5 minutes, transfer to 1-litre measuring cylinder and make up the volume with hot distilled water. Mix well and strain through a fine gauze (or mull cloth). Adjust the viscosity of the starch paste with small amount of distilled water so that 50 ml of starch paste when diluted to 100 ml with distilled water gives a flow time of about 80 ± 5 seconds at 50°C.

5.2.2 Weigh out accurately 1 g of the enzyme and 1 g of sodium chloride, dissolve them in distilled water and make up the volume to 1 litre.

5.2.3 Measure out 50 ml of the prepared starch paste (4 percent) in a 100 ml measuring cylinder, dilute to about 90 ml with distilled water, mix well and ascertain the temperature to be below 50°C (in case of testing pancreatic enzymes) or 70°C (in case of bacterial enzymes). Adjust *p*H to an optimum value recommended for the enzyme under test by adding small amount of sodium bicarbonate solution. Add 0.25 ml of the enzyme solution and make up to 100 ml. Mix well and transfer to a 250-ml beaker, and keep in a water-bath maintained at 50 ± 2°C (or 70 ± 2°C as the case may be). Note the time when enzyme is added. At the end of 15 minutes during which time the temperature is carefully maintained, suck into the fluidity tube sufficient amount of liquefied starch-enzyme paste and determine the outflow time of the solution from the top mark to the bottom mark of the fluidity tube.

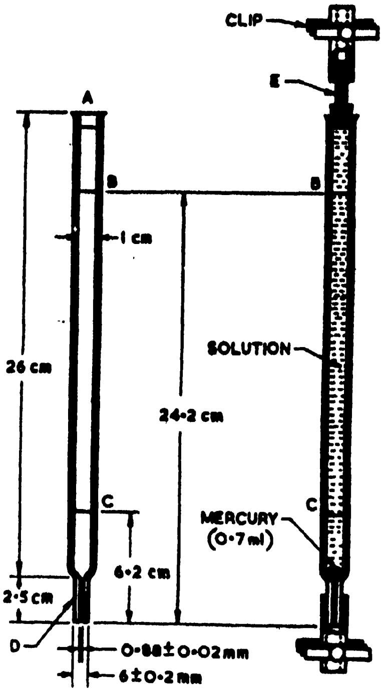
5.2.4 Repeat the procedure given as in **5.2.3** with 0.5, 0.75, 1.0, 2, 3, 4, 5 and 10 ml of the enzyme solutions and record the corresponding out-flow times.

5.2.5 Plot a graph showing the flow time against the corresponding concentration of enzyme used for test.

5.3 Repeat the test given in **5.2.1** to **5.2.4** with the other enzymes and similarly draw the graphs (as in **5.2.5**) for each of the other enzymes under test on the same graph paper.

5.4 From the graphs obtained in **5.2.5** and **5.3**, determine the amount of each enzyme under test required for liquefying the starch to the specific arbitrary flow time, say, between 30 to 40 seconds for the particular fluidity tube. Take four readings on the graph near the arbitrary flow time and determine the mean of these readings.

5.5 Compare the results (*see* **5.4**) to determine the relative desizing efficiency of the enzyme under test bearing in mind that higher the amount of enzyme required lesser is the desizing efficiency.



A = Fluidity tube
B = Top mark
C = Bottom mark
D = Capillary of the fluidity tube
E = Capillary tube

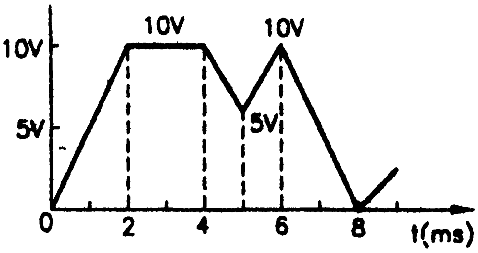
FIG. 1 FLUIDITY TUBE ASSEMBLY

ENGINEERING SERVICES EXAMINATION 1996 (E & T)

PAPER I (Conventional)

Time Allowed : Three Hours **Maximum. Marks : 200**

1. (*a*) A voltage source with waveform as shown in Fig. 1(*a*) is connected across a 30 mF capacitor at time $t = 0$. Find the values of the current in the capacitor at $t = 0.5$ ms and $t = 2.5$ ms. Also calculate the total energy delivered by the source till $t = 7.0$ ms. The capacitor has no charge prior to $t = 0$. (8)



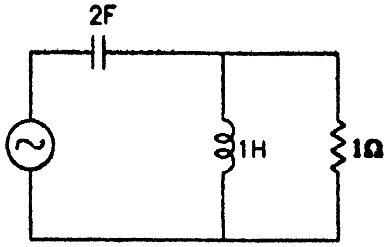
(*b*) Find the electric field vector E for an isotropic dielectric material when the displacement vector

$D = D_x i_x + D_y i_y + D_z i_z = 5.0\,(i_x + i_y - 2i_z)$ pC/m² and E is related to D as

$$\begin{bmatrix} D_x \\ D_y \\ D_z \end{bmatrix} = \varepsilon_0 \begin{bmatrix} 4 & 2 & 2 \\ 2 & 4 & 3 \\ 2 & 2 & 4 \end{bmatrix} \begin{bmatrix} E_x \\ E_y \\ E_z \end{bmatrix}$$

following usual notations. (8)

(*c*) Calculate the frequency at which the circuit of Fig. 1(*c*) will be in resonance. Will this frequency change if the positions of the inductor and capacitor are interchanged ? (8)



(*d*) Find the current i in the circuit of Fig. 1(*d*) using superposition theorem.

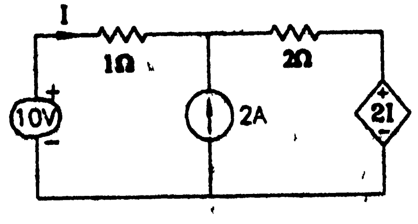


Fig. 1(d)

(*e*) Given an electric field 30 sin($10^{10}t$ + 15°) v/m, find the conduction and displacement current densities in a material with $\sigma = 4.0$ S/m, $\varepsilon = \varepsilon_0$ and $\mu = \mu_0$. Also determine the frequency (in Hz) at which the two densities will become equal in magnitude. (8)

(*f*) Determine the group velocity of a 12 GHz signal propagating in the TM_{11} mode in a rectangular waveguide of 4.0 cm × 2.0 cm cross section. (8)

(*g*) A galvanometer recorder with a 100 Ω coil resistance is connected to a transducer. The transducer acts as a voltage source in series with a 250 Ω resistance. The recorder response to a step input to the transducer is that of a second order system with a damping factor of 0.3. Find the resistance that should be put in parallel with the transducer so that the damping factor increases to 0.7. (8)

(*h*) The excitation to a two-terminal network is $4 + 5 \sin \omega t + 3 \cos 2\omega t$ volt, while the response current equals $0.3 \cos 2\omega t + 0.1 \cos (2\omega t - 45°)$ *A*. Find the average power supplied by the excitation source. (8)